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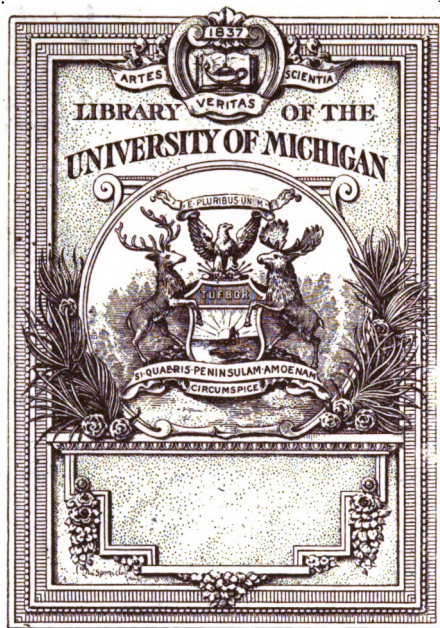
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AND
JOURNAL

OF THE
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TABLE OF CONTENTS.

	PAGE
On the Existence of Nickel-iron with Widmannstätten's Figures in the Basalt of North Greenland. By K. J. V. Steenstrup, C.M.S. (Two Woodcuts.)	1
A Chemical Examination of Greenland Telluric Iron. By Joh. Lorenzen	14
On some Specimens of Lava from Old Providence Island. By Prof. T. G. Bonney, D.Sc., F.R.S., F.G.S., President	89
Note on a New Mode of Occurrence of Garnet. By H. Louis, Assoc.R.S.M.	46
Note on a Case of Replacement of Quartz by Fluor Spar. By Prof. T. G. Bonney, D.Sc., F.R.S., F.G.S., President	48
Notes on "Enargite," from Montana, U.S.A. By Wm. Semmons, Past President of the Liverpool Geological Society	49
Analysis of an altered Siderite from Helton Beacon Lead Mine, near Appleby. By C. O. Trechmann, Ph.D., F.G.S.	52
Notes on a Picrite (Palæopicrite) and other Rocks from Gipps' Land, and a Serpentine from Tasmania. By Prof. T. G. Bonney, D.Sc., F.R.S., F.G.S., &c. President	54
The Crystallography of Bournonite. By H. A. Miers, M.A.	59
On the Tetartohedral Development of a Crystal of Tourmaline. By R. H. Solly, F.G.S. (Three Woodcuts.)	80
Application of the Periodic Law to Mineralogy. By Thos. Carnelley, D.Sc., Prof. Chemistry, University College, Dundee. (Communicated by Rev. W. W. Peyton.)	88
On Diatomaceous Deposits in Scotland. By W. Ivison Macadam, F.C.S., F.I.C.	87
On the Age and Origin of the Metallic Veins of the Upper Harz. By H. M. Cadell, B.Sc. (Communicated by the Rev. W. W. Peyton.)... ..	90
The Origin of the Andalusite-Schists of Aberdeenshire. By John Horne, F.R.S.E.	98
The Mineral Albertite, Strathpeffer, Ross-shire. By W. Morrison, M.A., &c. (Communicated by Rev. W. W. Peyton.)	101
On the Occurrence of Prehnite and other Minerals in the Rocks of Samson's Ribs and Salisbury Crags. By Andrew Taylor, F.C.S., A.G.S.E. (Communicated by Rev. W. W. Peyton.)	104
On Kyanite Localities in the North. By Thos. Wallace. (Communicated by Rev. W. W. Peyton.)	106
Note on Welsh Gold. By T. A. Readwin, F.G.S. (Abstract.)	108
Note on New Locality for Zoisite. By W. Hamilton Bell. (Communicated by Rev. W. W. Peyton.)	109
Address to the Mineralogical Society, 1884. By the Rev. Prof. Bonney, D.Sc., LL.D., F.R.S., President	111

	PAGE
Fine Crystals of Pale Lilac Calcite from Tankerville Mine, near Shelve, Shropshire. By R. H. Solly, F.G.S. (One Woodcut.)	120
Description of a Crystal of Parisite. By M. Guyot de Grandmaison	123
Further Notes on Enargite. By W. Semmons	124
Some Occurrences of Actinolite in Scotland. By Rev. W. W. Peyton. (Abstract.)	126
Observations on the Preparation of Mineral and Rock Sections for the Microscope. By John Ernest Ady	127
Index to Mineralogical Papers, &c. 1888. By H. A. Miers, M.A. (First Part.)	184
Abstracts and Notes	145
On the Physical and Geometrical Properties of Graphite. By Hj. Sjögren. (Communicated by H. Müller, Ph.D., F.R.S.) (Eight Woodcuts.)	151
Notes on a Recent Discovery of "Connellite." By W. Semmons	160
On Monazite from Cornwall, and Connellite. By H. A. Miers, M.A. (Two Woodcuts.)	164
Notes on Northern Minerals. By Thos. Wallace. (Communicated by the Local Secretary for Scotland.)	168
Connellite from Cornwall. By Dr. C. O. Trechmann. (One Woodcut.)	171
On the Chemical Composition of some Samples of Graphite from Knock, Aberdeenshire. By W. Ivison Macadam, F.C.S., F.I.C., &c.	172
Analysis of a Sample of Strontianite from Strontian, Argyllshire. By W. Ivison Macadam, F.C.S., F.I.C., &c.	178
On the Chemical Composition of Butyrellite (Dana). By W. Ivison Macadam, F.C.S., F.I.C., &c.	175
On an Occurrence of Rare Copper Minerals from Utah. By G. S. Mackenzie, Ph.D., F.I.C.	181
Index to Mineralogical Papers, &c. 1888. By H. A. Miers, M.A. (Second Part.)	188
Abstracts	192
Address to the Mineralogical Society, 1885. By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., P.G.S., &c.	195
Notes on Minerals from Cornwall and Devon. By R. H. Solly, F.G.S.	202
Note on Dr. Mackenzie's Paper read at the June Meeting ...	212
Some Results of the Crystallographic Study of Danburite. By Dr. Max Schuster. (Communicated by the President.)	218
Index to Mineralogical Papers, &c. 1884. By H. A. Miers, M.A.	217
Abstracts	234
Index, &c.	238

LIST OF PLATES.

PLATE I.

- Fig. 1. Figure of Bournonite from Phillips's Mineralogy.
 Fig. 2. Type of crystals from Endellion.
 Fig. 3. Type of Crystals from Liskeard.
 Fig. 4. Twin crystal, combined parallel to twin-plane.
 Fig. 5. A crystal from Endellion.
 Fig. 6. A crystal from Kapnik.
 Fig. 7. A crystal from Neudorf.
 Fig. 8. A crystal from Neudorf.
 Fig. 9. Type of 8-lings from Kapnik.
 Fig. 10. Type of cruciform crystals from Kapnik.

PLATE II.

- Fig. 11. A crystal from Liskeard.
 Fig. 12. Type of twin-crystals from Liskeard.
 Fig. 13. Twin crystal, combined perpendicular to twin-plane.
 Fig. 14. Scheme of Axes in repeated twin crystals.

PLATE III.—Diagrammatic Sectional Drawing of Lapidary's Lathe for Petrographical Work. *T.*, Top of table; *u.u.*, upright supporting legs; *J.*, middle joist; *tr.*, treadle; *cd.*, cord of treadle passing over pulley wheel (*p.v.*) to crank (*cr.*) of fly-wheel (*f.w.*); *st.*, strap from fly-wheel to spindle bearing wheel (*sp.w.*); *Sp.*, upper end of spindle; *Sp'*, lower part of spindle resting on bearing (*Sp. B*); *ub.*, and *lb.*, upper and lower bearings of fly-wheel, sunk in sliding-frame (*fr.*), which can be regulated by wooden screw (*w.s.*). The lower bearing, along with the inferior arm of the sliding frame, move in a limited groove in the joist (*J*), which is specially morticed at this part.

PLATE IV.—Enlarged Diagram of Grinding Apparatus. *i.*, Circular brass ring bordering aperture for upper end of spindle (*Sp*); it is provided with an upward projecting rim. The brass cap (*c*) acts as a steadying bearing to the spindle head (*Sp.*); *i'*, circular metal ring with upward projecting rim fastened on edge of central aperture of waste emery box (*b*): the brass protecting cap (*p*) comes over the edge of this rim.

and is apposed above to the free extremity of the spindle-head, thus effectually preventing the entry of dirt to the bearing (*c*); *i*"., iron pegs for securing box (*b*) in its place. *L.* lap, or grinding disc; *a.*, attachment pin of lap, is somewhat conical, and does not quite fill the slot (*s*); thus providing a grip which tends to become more firmly fixed during the process of grinding.

WORKING MEASUREMENTS.

~~Height~~ 22 inches

EXCERPT MINUTES OF COUNCIL MEETING

Held at 116 Victoria Street, April 3rd, 1884.

The Rev. Prof. BONNEY, D.Sc., F.R.S., President, in the Chair.

Prof. J. W. JUDD, F.R.S., was elected a Member of the Society.

EXCERPT MINUTES OF COUNCIL MEETING

ERRATA.

Two figures left out at page 314:—1 fig. *rutile*, line 5 from top. 1 fig. *gold*, centre of page.

Page 275, line 10 from foot, for "(of Edinburgh?—Ed.)"—*read* "of London."

6 from foot, for "one" *read* "an."

Page 277, line 16 from top, for "d" and "d" *read* "λ" and "λ."

Page 278, line 9 from foot, after "of these" *read* "best seen in fig. 3."

Page 281, dele paragraph commencing "The plate shows."

Page 287, line 11 from foot, for "pored" *read* "founded."

Page 291, line 6 from foot, for "form" *read* "from."

Page 292, line 3 from foot, for "Camer" *read* "Cama."

Page 294, line 19 from foot, after "Budweis" *read* "(See Tschermak, Mineral Mitth. 1873, p. 125)."

Page 296, line 18 from top, for "Sail an ruar" *read* "Sail Roar."

Page 305, line 26 from top, after "wayboards, or" insert "perhaps."

Page 307, line 12 from foot, for "Logan rock alike" *read* "Logan" rock alike.

Page 324, line 9 from foot, for "leave" *read* "leaves."

„ line 8 from foot, for "fissile" *read* "fossil."

"Forms of Silica." By John Ruskin, D.C.L., Slade Professor at Oxford (communicated by the Local Secretary for Scotland).

[Abstract.]

In this paper the attention of mineralogists was directed to some points in the habit of crystallisation of silica, and to the relations of colour to the state of substance of minerals, which the author considered had been

hitherto entirely neglected. He asked why "large and well developed quartz crystals are frequently topaz colour, a smoke colour—never rose colour, while massive quartz may be rose colour and pure white or grey, but never smoke colour; again, why amethyst quartz may continually, as at Schemnitz and other places, be infinitely complex and multiplex in crystallisation, but never warped, while smoky quartz may be continually found warped, but never in the amethystine way—multiplex; why, again, smoky quartz and cairngorm are continually found in short crystals, but never in the long slender one—as, to take instance in another mineral, white beryl was usually short, or even tabular, and green beryl long almost in proportion to its purity."

Referring to certain structures in the specimens of agates exhibited by him, the author affirmed that all the types of undulated structure were due to crystallisation only, and expressed his opinion that the contortions of the gneiss of the Alps are not due to wrinkling by pressure, but to crystallisation. He recognises six distinct states of siliceous substance, viz. flint, jasper, chalcedony, hyalite, opal, and quartz.

"The Application of the Periodic Law to Mineralogy." By Thomas Carnelley, D.Sc., F.C.S., Professor of Chemistry Univ. Coll. Dundee (communicated as above).

"The Origin of the Andalusite-Schists of Aberdeenshire." By John Horne, F.R.S.E., H.M.'s Geol. Survey.

"On the Occurrence of Prehnite and other Zeolites in the Rocks of Samson's Ribs and Salisbury Crags." By Andrew Taylor, F.C.S., A.G.S.E. (communicated as above).

"On a New Locality for Zoisite, Loch Garve, Ross-shire." By W. Hamilton Bell, F.G.S.E. (communicated as above).

"On Diatomaceous Deposits in Scotland." By Prof. W. I. Macadam, F.C.S., Hon. Sec. G.S.E.

"Notes on the Albertite Beds of Strathpeffer, Ross-shire." By William Morrison, M.A., Academy, Dingwall (communicated as above).

Mr. Thomson referred to the fact that an allied jet mineral was found imbedded in the oil-yielding bituminous shales of Midlothian. The substance only occurred in small quantities, the largest pieces not exceeding a pound in weight; it is capable of taking a fine polish, very similar to jet—in fact a jet-worker pronounced it at first to be Spanish jet.

"Kyanite Localities in the North, and Staurolite from Preshome, Engie, Banffshire." By Thomas Wallace, High School, Inverness (communicated as above).

"Scottish localities for Actinolite." By the Rev. W. W. Peyton.

"The Crystallography of Bournonite." By H. A. Miers, B.A., British Museum, Nat. Hist. Dept.

"Notes on the Metallic Veins of the Upper Hartz, Germany." By H. M. Cadell, B.Sc., H.M.'s Geol. Survey (communicated as above).

"On some New Forms of Tourmaline from Lockport, New York County." By R. H. Solly, F.G.S.

"On Welsh Gold," from the Mawddach Valley, Merionethshire. By T. A. Readwin, F.G.S.

ANNIVERSARY MEETING

Held at the Museum, Jermyn Street, on Tuesday, October 21st, 1884.

The Rev. Professor BONNEY, D.Sc., F.R.S., President, in the Chair.

The following were elected as Officers and Council for the ensuing year:—

President. REV. PROFESSOR T. G. BONNEY, D.Sc., LL.D., F.R.S.,
F.S.A., Pres. G. S.

Vice-Presidents. REV. S. HAUGHTON, M.D., F.R.S.
W. H. HUDLESTON, M.A., J.P., F.R.S.

Council. T. J. GIBB.
T. M. HALL, F.G.S.
JAMES I'ANSON, F.G.S.
H. M. PLATNAUER.
G. S. BOULGER, F.G.S., F.L.S.
J. STUART THOMSON.
C. O. TRECHMANN, Ph.D.
REV. PROF. T. WILTSHIRE, M.A., F.G.S.
T. W. DANBY, M.A., F.G.S.
J. J. DOBBIE, D.Sc.
L. FLETCHER, M.A., F.G.S.
PROF. W. J. LEWIS, M.A.

Treasurer. R. P. GREG, F.G.S., &c.

General Secretary. R. H. SCOTT, M.A., F.R.S.

Foreign Secretary. T. DAVIES, F.G.S.

The Hon. Secretary, Mr. R. H. Scott, F.R.S., read the following Report of the Council.

REPORT.

The year which has just passed over us has been marked by an important step in the history of the Society, and one which the Council doubt not will materially conduce to its prosperity in the future. This has been the fusion with the Crystallogical Society, which was carried into effect at the Special General Meeting in December last.

The Balance Sheet for the year 1883, which appeared in Part XXVI. of the Journal, shows signs of steady improvement. It closes with a Balance to Credit of £17 0s. 4d., whereas the year had commenced with an adverse Balance of £6 2s. 9d. The excess of assets over all liabilities on the 1st of January was £191 10s. 6d., being an increase of £16 11s. 5d. on the amount for the previous year.

At the present date, October, the only unpaid account for printing is that for the last No. of the Journal (No. 27). The total amount of other accounts outstanding is £12 10s., and there is a balance at the bank more than sufficient to meet it.

The number of Members shows a slight increase, owing to the election of the Members of the Crystallogical Society, and in addition five new Members have been elected. The Council regret to say that two Members have been removed by death, Mr. S. F. Bawden and Prof. Q. Sella, the latter of whom has left a gap among the statesmen as well as the scientific men of Italy which it will be hard to fill. Six Members have resigned, and the names of as many more have been removed from the list for non-payment of subscriptions for three years.

The Society has held its three Meetings during the Session : two of them, in December and February respectively, have taken place, by kind permission of the Director-General of the Geological Survey, at the Museum, Jermyn Street.

The Scotch Meeting, the date of which was postponed from May 12th to June 24th in order to suit the convenience of the visitors to the Forestry Exhibition in Edinburgh, has been a brilliant success, as no less than thirteen papers were read.

Of the papers which have been laid before the Society during the Session, the Council would especially mention those by Prof. Steenstrup and the late Dr. Lorenzen on the so-called Meteoric Iron first brought by Baron Nordenskiöld from the Basalt of Greenland. The Council hope that the appearance of these communications in English will attract to them a wider notice in this country than if they had remained in the original language (Danish) in which they appeared, in Part 4 of *Meddelelser om Grönland*.

Two parts of the Journal have appeared since the last anniversary, and a third is in the press in an advanced stage.

The issued parts of the Proceedings of the Crystallological Society, two in number, have been presented to the Council, and distributed to the Members.

The President then delivered his Address.

On the Motion of Mr. Scott, seconded by Mr. Hudleston, the President was requested to allow his address to be printed.

The following papers were read :—

Mr. W. Semmons, "Further Notes on Enargite."

Mr. R. H. Solly, F.G.S., "Fine Crystals of Lilac Calcite from Tankerville Mine, Shropshire."

Monsieur Guyot de Grandmaison exhibited a fine specimen of Parisite.

Mr. Rudler exhibited some specimens from the Ludlam Collection, and Mr. T. Davies some from the British Museum.

(The President's address and the papers read at the Anniversary Meeting will appear in No. 29.)

LIST OF DONATIONS.

December 1884.

- Transactions of the North of England Institute of Mining and Mechanical Engineers,
Vol. XXXI. Part V.; Vol. XXXII. Parts I. to V.; and Vol. XXXIII. Parts I.
to VI. Presented by the Institute.
- Proceedings of the Bristol Naturalists' Society. New Series, Vol. IV. Parts I. & II.
Presented by the Society.
- The Naturalist, Dec. 1884. Presented by the Editor.
- Transactions of the Yorkshire Naturalists' Union. Part 7.
Presented by the Union.
- Chapters on the Mineralogy of Scotland (Chapter VII.). By Prof. M. F. Heddle.
Presented by the Author.
- The Mineral Resources of New Zealand. By Henry Bramwell, M.I.C.E.
Presented by the Author.
- On the Bingera Meteorite; on the Deniliquin or Barratta Meteorite; on the Chemi-
cal Composition of certain Rocks from New South Wales; and on Rocks from
New Britain and New Ireland. All by Prof. A. Liversidge, F.R.S.
Presented by the Author.
- On the Discovery of Emeralds in North Carolina; on some North Carolina Minerals;
and on a phenomenal pocket of fluid-bearing Quartz Crystals. By W. E. Hidden.
Presented by the Author.
- On Hiddenite. By E. S. Dana. Presented by W. E. Hidden, Esq.
- On the Glaciation of Newfoundland. By Alex. Murray, F.R.S.
Presented by the Author.
- On the Iron Ores of the North-eastern part of the Jabalpur District; on New Faces
observed on Crystals of Stilbite from the Western Ghâts; and on some
Mineral Resources of the Andaman Islands. By F. R. Mallet.
Presented by the Author.
- The Science Monthly. Vol. I. No. 8. Presented by the Editor.
- The American Journal of Science. Current Numbers. Presented by the Editors.
- The American Chemical Journal. Edited by Ira Remsen. Presented by the Editor.
- Transactions and Annals of the New York Academy of Sciences. Current Numbers.
Presented by the Academy.
- Proceedings of the Academy of Natural Sciences of Philadelphia. Current Num-
bers. Presented by the Academy.
- American Journal of Mathematics. Edited by J. J. Sylvester. Current Numbers.
Presented by the Editor.
- Smithsonian Institution. Reports for 1881 and 1882. Presented by the Institution.
- Twelfth Annual Report of the United States Geological and Geographical Survey of
the Territories under Dr. F. V. Hayden. 2 Vols. with Atlas; Mineral Resources
of the United States, by Albert Williams, jun.; Bulletin of the United States
Geological Survey, No. I.; Second Annual Report of the United States Geolo-

gical Survey, by Major Powell; Tertiary History of the Grand Cañon District, with Folio Atlas, by Clarence E. Dutton.

Presented by the United States Geological Survey.

Reports of Progress of the Geological Survey of Canada for 1880, '81 and '82. By

A. R. C. Selwyn, F.R.S.

Presented by the Geological Survey of Canada.

Canadian Mining Review. Vol. I. Nos. 7 and 8.

Presented by the Editor.

Reports of the Geological Exploration of New Zealand during 1882 and 1883-4. By

Dr. J. Hector, F.R.S.

Presented by the Author.

Journal of the Royal Society of New South Wales. Edited by A. Liversidge, F.R.S.

Vol. XVI.

Presented by the Editor.

Report of the Trustees of the Australian Museum, New South Wales.

Presented by the Trustees.

Report of the Chief Inspector of Mines, Victoria, for 1881.

Presented by the Inspector.

Publications de l'Institut Royal Grand-Ducal de Luxembourg, Tome XIX.

Presented by the Institute.

Annales de la Société Géologique de Belgique, Tome IX. Presented by the Society.

Bulletin de la Société Minéralogique de France. Current numbers.

Presented by the Society.

Discours prononcé par M. Daubrée aux Funérailles de M. Delesse.

Presented by M. Daubrée.

Mineralogische und Petrographische Mittheilungen, von G. Tschermak. Current Numbers.

Presented by the Editor.

Zeitschrift für Krystallographie und Mineralogie, von P. Groth. Current Numbers.

Presented by the Editor.

Zeitschrift für Naturwissenschaften. Current Numbers. Presented by the Editor.

Bericht des Vereins für Naturkunde zu Cassel, XXIX. and XXX.

Presented by the Society.

Vorträge und Mittheilungen. Von G. Vom Rath. Presented by the Author.

Jahrbruch und Verhandlungen der K. K. Geologische Reichsanstalt. Current Numbers.

Presented by the Institute.

Beobachtungen an Harzer Mineralien. Von Otto Luedecke.

Presented by the Author.

Krystallographische Untersuchungen an homologen und isomeren Reihen. Von Dr. Aristides Brezina. Theil I.

Presented by the Author.

Ueber Melilith und Melilithbasalte, von Alf. Stelzner; Ein Beitrag zur Kenntniss der Flüssigkeiteinschlüsse in Topas, von Theodor Erhard und Alf. Stelzner; Ueber die Umwandlung der Destillationsgefäße der Zinköfen in Zinkspinnell und Tridymit, von Hans Schulze und Alf. Stelzner; On Crystallized Dauburite from Russell, St. Lawrence Co., N.Y., by G. J. Brush and E. S. Dana; On the Mineral Locality at Branchville, Connecticut; 4th paper, by G. J. Brush and E. S. Dana; On the elevated Coral-reefs of Cuba, by W. O. Crosby; On American Sulpho-arsenides of Mercury, by G. J. Brush; Sui Fossili del Calcare dolomitico del Chaberton, di B. Gastaldi; and a number of German Mineralogical Pamphlets.

All presented by Dr. C. Le Neve Foster.

Atti della R. Accademia dei Lincei. Current Numbers of the Transunti.

Presented by the Academy.

Atti della Società Toscana di Scienze Naturali. Current Numbers.

Presented by the Society.

R. Comitato Geologico d' Italia. Current Numbers of the Bolletino.

Presented by the Institute.

Meddelelser om Grønland, udgivne af Commission for Ledelsen af de Geologiske og Geographiske Undersøgelser i Grønland. Parts 2, 3, 4, 5 and 6.

Presented by Prof. Johnstrup.

Bidrag til Kjenskab til Bræerne og Bræ-isen i Nord-Grønland, af K. J. V. Steenstrup ;
and Om Forekomsten af Nikkeljern med Widmannstättenske Figurer i Basalt
i Nord-Grønland, af K. J. V. Steenstrup.

Presented by the Author.

Mineralogiska och petrografiska Meddelander, af F. J. Wiik.

Presented by the Author.

Krystallographisk-Chemiske Undersøgelser, af Th. Hiertdahl.

Presented by the Author.

Tjenstförrättande Bergintendentens underdåga berättelse för år 1882 (Finland).

Presented by Prof. E. H. Furnhjelm.

Censo General de la Provincia de Buenos Ayres, demografico, agricolo, industrial, comercial, &c., verificado el 9 de Octubre de 1881 bajo la administracion del Doctor Don Dardo Rocha ; The Argentine Republic, by Francis Latzina ; Sistema de Medidas y Pesas de la Republica Argentina ; Annuaire Statistique de la Province de Buenos Ayres, Deuxième Année, 1882 ; La Sierra de Curá-Malal, por el Dr. Eduardo Ladislao Holmberg ; and Current Numbers of the Annales de la Sociedad Cientifica Argentina.

All presented by the Society.

El Comercio, Oct. 15th, 1884.

Presented by the Editor.

EXCERPT MINUTES OF COUNCIL MEETING.

Held at the Museum, Jermyn Street, December 9th, 1884.

The Rev. Prof. BONNEY, D.Sc., F.R.S., President, in the Chair.

Mr. FRANK JOHNSON, Associate, was elected a Member.

EXCERPT MINUTES OF COUNCIL MEETING.

Held at the Museum, Jermyn Street, March 10th, 1885.

The Rev. Prof. BONNEY, D.Sc., President, in the Chair.

Messrs. JAS. CURRIE, and ALFRED HARKER, B.A., and Monsieur ALFRED LACROIX, were elected Members.

The audited Balance Sheet for 1884 was submitted and ordered to be printed and issued (p. x.).

Mineralogical Society—Abstract of Receipts and Payments from 1st January to 31st December, 1884.

RECEIPTS.		PAYMENTS.	
	£ s. d.		£ s. d.
Balance from year 1883	17 0 4	Printing	132 15 6
Subscriptions paid in advance	5 4 0	Illustrations	19 11 0
" " " "	93 17 0	Expenses of Meetings	9 13 8
Arrears	17 1 0	Clerical Expenses	7 0 0
Entrance Fees and Life Compositions	17 1 0	Postages, Parcels, &c.	14 12 8
Sale of Publications	33 10 0	Investments	19 0 3
Dividends	5 0 3	Sundry Small Items	3 13 5
		Balance	0 1 1
	<u>£188 13 7</u>		<u>£188 13 7</u>

Examined and compared with the vouchers and found correct. (Signed)

BENEDICT KITTO, }
F. W. RUDLER, } AUDITORS.

ASSETS AND LIABILITIES on 31st December, 1884.

LIABILITIES.		ASSETS.	
	£ s. d.		£ s. d.
Williams & Strahan, Printing	13 13 4	Subscriptions for 1884 unpaid	20 14 0
Mintern Bros., Plates	3 19 0	1883	9 9 0
Clerical Expenses (1884), including Editing Magazine	16 16 0	New 3 " Per Centa. £179 12s. 10d. at 99½	178 10 4
Subscriptions paid in advance	5 4 0	Stock of Publications (average yearly sale)	39 9 10
Excess of Assets over Liabilities	215 12 4	Simpkins & Co., Sale of Publications	5 13 7
		Sale of Publications by Office—unpaid	1 7 9
	<u>£255 4 6</u>		<u>£255 4 6</u>

Examined and compared with the vouchers and found correct.

(Signed)

ROBERT H. SCOTT,
General Secretary.

GENERAL MEETING.

Held at the Museum, Jermyn Street, December 9th, 1884.

The Rev. Prof. BONNEY, D.Sc., F.R.S., President, in the Chair.

The following papers were read :—

J. ERNEST ADY, Esq.—“ Observations on the Preparation of Mineral and Rock Specimens for the Microscope.” (p. 127.)

Professor HEDDLE, F.R.S.E.—“ The Geognosy and Mineralogy of Scotland (Ross and Cromarty).” Part I., The Islands.

Mr. J. H. COLLINS, F.G.S., exhibited a specimen of tinstone from Irish Creek, Rockbridge County, Virginia, U.S.A., a new locality for that mineral. It consisted of an indistinctly crystallised cleavable mass of light brown colour, pretty much like the cassiterite from the North of Spain. It was, however, remarkable for its greatly inferior hardness, which did not exceed that of felspar on the cleavage planes. It had evidently been broken from a vein.

GENERAL MEETING.

Held at the Museum, Jermyn Street, March 10th, 1885.

The Rev. Prof. BONNEY, D.Sc., F.R.S., President, in the Chair.

The following papers were read* :—

Herr HJ. SJÖGREN.—“ On the Physical and Geometrical Properties of Graphite.” (Communicated by Dr. Hugo Müller, F.R.S.)

Mr. W. SEMMONS.—“ Some Notes on a recent Discovery of Connellite.”

Mr. Fletcher exhibited a portion of a Meteorite consisting of a mass of iron $17\frac{1}{2}$ lbs. weight, which had been found at Yundagin, 90 miles east from York, West Australia, and forwarded by the Rev. C. G. Nicolay to the Society for presentation to the British Museum.

* These Papers will appear in the next No.

LIST OF DONATIONS

From January 1st to March 31st, 1885.

-
- The American Journal of Science, Vol. XXIX., No. 169. Presented by the Editors.
 The American Chemical Journal, Vol. XI., No. 5. Do.
 The Naturalist, for Jan., Feb. and March, 1885. Do.
 Descriptive Sketch of the Physical Geography and Geology of the Dominion of
 Canada, by A. R. C. Selwyn and G. M. Dawson, with Geological Map; also
 Comparative Vocabularies of the Indian Tribes of British Columbia. By W.
 Fraser Tolmine. Presented by the Geological Survey of Canada.
 Fourth Annual Report of the State Mineralogist of California.
 Presented by the California State Mining Bureau.
 Report on the Geology of the Kimberley District, West Australia. By E. T.
 Hardman. Presented by the Author.
 Notes on the Progress of Mineralogy in 1884. By H. Carvill Lewis.
 Presented by the Author.
 Verhandlungen der k.k. geologischen Reichsanstalt, Nos. 1 to 18, 1884; No. 3,
 1885; also Jahrbuch der k.k. geolog. Reichsanstalt, Vol. XXXIV., No. 4.
 Presented by the Geological Institute of Vienna.
 Mineralogische und petrographische Mittheilungen. Herausgegeben von G.
 Tschermak. N.F. Vol. VI., Nos. IV., V., VI. Presented by the Editor.
 Ueber die Grenzen der Zechstein-formation und der Dyas überhaupt. Von Geh.
 Hofrath Prof. Dr. H. B. Geinitz. Presented by the Author.
 Annales de la Société Géologique de Belgique. Vol. XI., 1883-4.
 Presented by the Society.
 Atti della Reale Accademia dei Lincei. Transunti; Vol. VIII., fas. 16. Rendiconti,
 Vol. I., fas. 1 to 6. Presented by the Society.
 Il Porfido del Vallone di Roburent del Dottore Guiseppe Piolti; also, Il Calcare del
 Monte Tabor. By the same Author. Presented by the Author.
 Anales de la Sociedad Científica Argentina. Tomo XVIII., No. 6. Tomo XIX.,
 Nos. 1 and 2.

EXCERPT MINUTES OF COUNCIL MEETING

Held at 116 Victoria Street, June 25th, 1885.

The Rev. Prof. BONNEY, D.Sc., President, in the Chair.

MESSRS. F. H. BUTLER and H. ROBINSON were elected members.

GENERAL MEETING

*Held at the Rooms of the Philosophical Society, 207 Bath Street, Glasgow,
Tuesday, June 16th, 1885.*

Mr. JOHN YOUNG, F.G.S., of the Hunterian Museum, Glasgow (Visitor),
in the Chair.

Mr. G. S. MACKENZIE, Ph.D., read a paper—"On an Occurrence of rare
Copper Minerals from Utah." (p. 181.)

Mr. D. C. Glen, F.G.S. (Visitor) exhibited a series of mineral specimens from the district round Glasgow, and from one or two other localities within the area of the Estuary of the Clyde, upon which he and the Chairman made some remarks. The specimens consisted of examples of the group of Zeolitic minerals that are found in the basic olivine traps of the Kilpatrick and Renfrewshire hills, and embraced crystallised varieties of Prehnite, analcite, Laumontite, natrolite, Thomsonite, stilbite, Heulandite, Chabasite, &c. Mr. Glen also exhibited specimens of native copper from the trap of Boyleston Quarry, Barrhead, and some crystals of the rare mineral Greenockite from the trap of the Bishopton Tunnel, also specimens of the Arran pitchstones, and spherulites, from Corriegills and Invercloy.

The Local Secretary read the following paper:—

"On Monazite and Connellite from Cornwall." By H. A. MIERS, M.A.
(p. 164.)

The Chairman, Mr. John Young, F.G.S., exhibited a series of specimens and polished transparent sections of "Cone-in-Cone" structures from the carboniferous strata of Western Scotland, and stated that recently he had been led to make a careful examination of this peculiar structure in specimens that he had obtained at Waterland Quarry, Dunlop, Ayrshire. In these specimens the cone structure is well preserved, and the upward termination of the cones on the surface of the bed is so clearly displayed that he has

been led to form a different explanation as to the origin of the structure from any of those formerly advanced. He stated, that in the explanations of former observers, "cone-in-cone" had been ascribed to the action of various causes, such as chemical precipitation, the action of pressure on concretions in process of formation, and to a kind of crystallisation in the stratum after the deposition of the sediment of which the bed is composed. Mr. Young pointed out, that in his specimens there are revealed external characters and points of internal structure which apparently had not been recorded, or at all events had been overlooked in all the descriptions that had come under his notice. Briefly stated, the following are the chief conclusions to which he had been led. 1st. That "Cone-in-cone" was in all probability formed by the upward escape of gases, generated in the sediments in which it is found by the decomposition of the organisms present; these being either plant remains, Entomostraca, shells or fishes, as seen in the specimens exhibited. 2nd. That the cones start from a point near the lower portion of the stratum, and ascend upwards; their bases gradually expanding as they reached the surface of the bed. 3rd. That there exists in all the cones, large and small, a central axis or tube, through which the gases escaped that elevated the calcareous sediment in successive layers, and of which the cone structure is built up. 4th. That the transverse wrinkling, seen upon the inner surface layers of the cones, appears to be due to a creeping downwards through gravitation of the plastic sediment upon the slopes of the cones in the intervals between the ebullition of the gases that elevated the sediment. 5th. That a thin layer of clay of varying thickness is seen to exist between the several calcareous layers of the cones, and which was probably deposited from the waters in which the cone structure was being formed; and that it is owing to this layer of clay that the cones now, in most instances, separate readily from one another when the stratum is fractured vertically. Transparent sections also show that this layer of clay must have been deposited within the cones whilst their bases remained open, the argillaceous layers being seen to unite with the central axis or tube. 6th. That coprolites of fishes, shells or other solid materials in the sediment are seen to have often interfered with the formation of the cone structure in their vicinity, and are sometimes found plugging up the orifice of a cone. 7th. That the cone structure was brought to a close in the stratum in which it exists by the gradual decrease of the gases that generated the mechanical action. In the Waterland specimens we find that the bases of the larger cones, where they terminate on the surface of the bed, are filled with groups of small minor cones, and that these continued in many instances

to erupt sediment, layer within layer, until their bases now rise above the general level of the stratum, indicating that the last ebullition of the gases was small in quantity and very feeble. Mr. Young in conclusion stated, that his remarks, and the explanation he offered on "cone-in-cone" structure, were wholly founded upon the specimens and sections exhibited, and in these he thought it was clearly evident that the formation of the structure was contemporaneous with the deposition of the sediment, which, from the nature of the organisms, appears to have been deposited over the area of wide, shallow, freshwater lakes, either as a thin stratum, or in lenticular or nodular masses. He had carefully studied the specimens exhibited, in connection with the other explanations of the structure that had been recorded, but he failed to find in the chemical, crystalline, or concretionary theories, an explanation that would serve to illustrate the varied points of structure that are seen in the best preserved specimens of "cone-in-cone" from Western Scotland.

The following Papers were then read :—

"Notes on Northern Minerals." By THOMAS WALLACE, Inverness (Communicated by the Local Secretary). (p. 168.)

"On the Chemical Composition of some Samples of Graphite from Aberdeen." By W. IVISON MACADAM, F.C.S., F.I.C., &c. Edinburgh. (p. 172.)

"On the Chemical Composition of Butyrellite." By same. (p. 175.)

"Analysis of a Sample of Strontianite from Strontian." By same. (p. 173.)

The Local Secretary expressed the thanks of the Society to the Geological Society of Glasgow, and especially to Mr. Murdoch its Hon. Secretary, for the interest which had been taken in organising the present meeting.

The meeting closed with a vote of thanks to the Chairman.

EXCERPT MINUTES OF COUNCIL MEETING.

Held at the Museum, Jermyn Street, October 20th, 1885.

The following gentlemen were elected Members—

C. C. ROSS, M.P., Carne, Penzance.

F. R. W. DAW, Marytavy, Tavistock.

JOHN DAW, Jun., Bommelo, Haugesund, Norway.

G. F. KUNZ, Hoboken, New Jersey.

The Draft Report was adopted for submission to the Anniversary Meeting.

MINUTES OF THE ANNIVERSARY MEETING.

Held at the Museum, Jermyn Street, October 20th, 1885, at 8 p.m.

The President, The Rev. Prof. BONNEY, D.Sc., in the Chair.

Messrs. Solly and Miers were appointed Scrutineers of the Ballot for Officers and Council; they reported that 50 members had voted, and that the following were duly elected :—

<i>President.</i>	L. FLETCHER, M.A., F.G.S.
<i>Vice Presidents.</i>	Rev. S. HAUGHTON, M.D., F.R.S. Rev. Professor T. G. BONNEY, M.A., D.Sc., F.R.S.
<i>Council.</i>	C. A. BURGHARDT, LL.D. A. GEIKIE, LL.D., F.R.S. Rev. H. GURNEY, M.A. HUGO MÜLLER, Ph.D., F.R.S. Rev. W. W. PEYTON.
	(In place of Messrs. Fletcher, Gibb, Hall, I'Anson and Platnauer, the retiring Members.)
<i>Treasurer.</i>	R. P. GREG, F.G.S., &c.
<i>General Secretary.</i>	R. H. SCOTT, M.A., F.R.S.
<i>Foreign Secretary.</i>	T. DAVIES, F.G.S.
<i>Auditors.</i>	B. KITTO, F.G.S. F. W. RUDLER, F.G.S.

The Secretary then read the following Report :—

REPORT OF THE COUNCIL OF THE MINERALOGICAL SOCIETY FOR 1884-5.

The Balance Sheet for the year 1884, which appeared in No. 28 of the Journal, showed that the finances of the Society were in a healthy condition, the excess of Assets over Liabilities amounting to £215 12s. 4d.

The number of Members and Associates elected during the year has been seven, and the number of resignations five, while the names of four Members and one Associate have been removed from the list for non-payment of subscriptions for three years. The Council regret that they have to report also the death of Alexander Murray, Esq., C.M.G., of St. John's, Newfoundland.

Three Meetings have taken place since the last Anniversary; those in December and March were held in the Museum of Economic Geology, by kind permission of the Director-General

of the Survey ; the third was held in Glasgow in the month of June, in the rooms of the Philosophical Society. This, the second Scottish Meeting, was, like its predecessor in 1884, a decided success.

Three parts of the Journal have been issued during the year. Among their contents the Council would especially draw attention to Mr. Miers' contributions, including his careful Index to the Mineralogical literature of the year.

Herr Sjögren's paper on Graphite also deserves notice ; it is a translation from the Swedish, as it originally appeared in the *Forhandlingar* of the Stockholm Academy.

In conclusion, the Council would only remind the Members that it is very desirable that they should co-operate actively in the working of the Society by the contribution of papers to be read at its Meetings and published in its Journal. It is by such co operation alone that the Society can be maintained in a state of vigorous activity.

On the motion of the President, seconded by the Hon. Secretary, the Report was adopted.

The President then delivered his Address (p. 195).

Prof. LEWIS then said:—

I rise to propose that the Society return its hearty thanks to Professor Bonney for the interesting Address which he has been good enough to give us, and for the able and pleasant manner in which he has presided over us during the last year.

The first portion of Prof. Bonney's address discussed an important but very difficult subject, the definition of the species, and the way in which it should be named. In the present state of our knowledge any thing approaching to a systematic nomenclature is hardly possible, and it is, therefore, probable that our present trivial names are the best, as they will stand less in the way of a systematic nomenclature than any others. In a discussion as to nomenclature which I had with Professor W. H. Miller some ten years ago, he expressed himself most strongly in favour of trivial names for minerals, and I have no doubt that he had this in mind. The definition of the genus or species is a matter which requires a wide knowledge of minerals—wider far

than is common amongst mineralogists. But any one who has ever attempted a classification of minerals will have learnt that the problem before him is one no less difficult than the well-known one of the librarian.

The second subject, the artificial formation of minerals, discussed by Professor Bonney, is one in which much progress has been made, and which is daily becoming more important. Besides the actual experiments made in our laboratories, we have, in various parts of the world, minerals being formed in a manner permitting of easy observation; and now that we have mineralogical teaching in London, it is to be hoped that our mining engineers will receive a sufficiently general education to aid us by recording the changes which they perceive going on in the districts where they may be working. I can see few ways in which a greater or more important addition to our knowledge could be made.

I have, therefore, to request Prof. BONNEY to allow his Address to be printed in the Journal.

The motion was seconded by Mr. MIERS.

Professor BONNEY then vacated the Chair, which was taken by Mr. FLETCHER, the newly elected President.

The following Papers were read:—

H. A. MIERS, M.A.—“On a Crystal of Orthoclase.”

R. H. SOLLY, F.G.S.—“Notes on Minerals from Cornwall and Devon.” (p. 202.)

Dr. MAX. SCHUSTER, of Vienna (Communicated by the President).—“Some Results of the Crystallographic Study of Danburite.” (p. 213.)

The Hon. Sec. read the following letter:—

Chemical and Metallurgical Laboratory,
Pretoria, July 27th, 1885.

S.A.B.

The Secretary,

The Mineralogical Society,
London.

Dear Sir,

I enclose a small sample, together with my analysis, of a mineral found near here. It contains, as you will see, after deducting the quartz

MINERALOGICAL SOCIETY.

DONATIONS TO THE LIBRARY.

From April 1 to December 31, 1885.

- Third and Fourth Annual Reports of the United States Geological Survey, by J. W. Powell; Geology of the Comstock Lode, with Atlas, by G. F. Becker; Comstock Mining and Miners, by Elliot Lord; The Copper-bearing Rocks of Lake Superior, by R. D. Irving; Palaeontology of the Eureka District, by C. D. Walcott; Older Mesozoic Flora of Virginia, by W. D. Fontaine; Silver-Lead Deposits of Eureka, by J. S. Curtis; and Nos. 2 to 6 of the Bulletins of the U. S. Geological Survey. All presented by the United States Geological Survey.
- The Rudiments of Mineralogy, by A. Ramsay, 3rd Edition; and the Prospector's Handbook, J. W. Anderson. Presented by Messrs. Crosby Lockwood & Co.
- The American Journal of Science, monthly. Presented by the Editors.
- The Young Mineralogist, Nos. 9 and 10. Presented by the Editor.
- The American Chemical Journal, Vol. 7, Nos. 1 to 5. Presented by the Editor.
- The Naturalist, monthly. Presented by the Editor.
- Transactions of the North of England Institute of Mining and Mechanical Engineers. Vol. XXXIV., Parts II. to VI.; and an Account of the Strata of Northumberland and Durham as proved by borings (F to K). Presented by the North of England Institute of Engineers.
- Transactions of the Yorkshire Naturalists' Union, Part 8. Presented by the Union.
- Proceedings of the Bristol Naturalists' Society, N.S., Vol. IV. Part III. Presented by the Society.
- Reports of Progress of the Geological and Natural History Survey of Canada for 1882-4, with Maps; and Catalogue of Canadian Plants, by John Macoun. Presented by the Geological Survey of Canada.
- Proceedings of the Academy of Natural Sciences of Philadelphia, Parts I to III., 1884. Presented by the Academy.
- Proceedings of the Colorado Scientific Society, Vol. I. Presented by the Society.
- Annual Report of the Department of Mines of New South Wales for 1884. Presented by the Department of Mines, Sydney.
- Journal and Proceedings of the Royal Society of New South Wales, Vol. XVIII. Edited by A. Liversidge, F.R.S. Presented by the Society.
- Analysis of Slate in contact with Granite, from Preservation Inlet, New Zealand; and On some New South Wales Minerals. Both by A. Liversidge, F.R.S. Presented by the Author.
- The Volcanoes of Barren Island and Narcondam, by J. W. Mallet, Geological Survey of India. Presented by the Author.
- An Account of the Eruption of Mount Vesuvius, by J. M. Black. Presented by the Author.
- Smithsonian Report for 1883. Presented by the Smithsonian Institution.
- Annuaire géologique universel, 1885. Presented by Dr. Dagnicourt.

Description pétrographique des Roches des Terrains crallins primaires et sédimentaires du Massif de la Chaine du Mont Blanc. Par Venance Payot.

Presented by the Author.

Recherches sur la Composition et la Structure des Phyllades Ardennais, par A. Renard.

Presented by the Author.

Bulletin de la Société Minéralogique de France. Tome VIII. Nos. 1 to 7.

Presented by the Society.

Annales de la Société géologique de Belgique. Tome X., 1882-3.

Presented by the Society.

Catalogue des Ouvrages de Géologie, de Minéralogie et de Paléontologie, ainsi que des Cartes géologiques. Par G. Dewalque.

Presented by the Geological Society of Belgium.

Mineralogische Notizen; Vorträge und Mittheilungen; and mineralogische Mittheilungen, Neue Folge. All by G. Vom Rath.

Presented by the Author.

Colemanit aus Californien. Von C. Bodewig und G. Vom Rath.

Presented by Prof. Vom Rath.

Ueber Vanadate und Jodsilber von Lake Valley, Donna Anna County, New Mexico. Von F. A. Genth und G. Vom Rath.

Presented by G. Vom Rath.

Ueber Datolith von Casarza, und Calciumhydroxyd; und Ueber Thüringer Mineralvorkommnisse. Von Dr. O. Luedecke.

Presented by the Author.

Ein Beitrag zur Morphologie des Leucits. Von H. Rosenbusch.

Presented by the Author.

Mineralogische und petrographische Mittheilungen. Von G. Tschermak. Neue Folge. Bd. VII. Heft 1, 2, 3.

Presented by the Editor.

Zeitschrift für Krystallographie und Mineralogie. Von P. Groth. Bd. IX. Heft 4 to 6; X. 1 to 6; and XI. 1.

Presented by the Editor.

Zeitschrift für Naturwissenschaften, 4 Folge, Band III. Heft 3 to 6; and IV. 1.

Presented by the Editor.

Jahrbuch der K. K. Geologischen Reichsanstalt, Bd. XXXV. Heft 1 to 4; and Verhandlungen, 1885.

Presented by the Institute, Vienna.

Grundfjeldsprofillet ved Mjøsens sydende. Af Dr. Th. Kjerulf.

Presented by the Author.

Mineralogiska och petrografiska Meddelanden, X., af F. J. Wiik.

Presented by the Author.

Bolletino del R. Comitato Geologico d' Italia. Nos. 11 and 12, 1884, and 1 and 2, 1885.

Presented by the Geological Survey.

Atti della Società Toscana di Scienze Naturali; Memorie, Vol. IV. fasc. 3; Vol. VI. fasc. 2; and Processi Verbal, Vol. IV.

Presented by the Society.

Atti della Reale Accademia dei Lincei. Rendiconti, Vol. I. fasc. 7 to 28; Vol. II. fasc. I.

Presented by the Academy.

Rivista geologica dei Terrani della Brianza. Nota del Sig. Giovanni Battista Villa.

Presented by the Author.

Osservazioni Meteorologiche fatte al R. Osservatorio de Campidoglio.

Presented by the Accademia dei Lincei.

Anales de la Sociedad científica Argentina. April and May 1885.

Presented by the Society.

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THE MINERALOGICAL MAGAZINE

AND

JOURNAL

OF THE

MINERALOGICAL SOCIETY OF GREAT BRITAIN AND
IRELAND.

No. 27.

JULY 1884.

Vol. VI.

I. *On the Existence of Nickel-iron with Widmannstätten's Figures in the
Basalt of North Greenland.*

By K. J. V. STEENSTRUP, C.M.S.

(Translated from Meddelelser fra Grönland. Heft 4. 1888.)

AMONG the minerals found in meteorites, there is none which has attracted the general notice to such a degree as the metallic nickel-iron, especially from the fact that it has hitherto never been seen for certain in any telluric rocks. Nay, so much stress was laid upon this latter circumstance, that such iron was thought never to occur here on earth without having been carried to us from the outer universe, and ever since Chladni's report on the iron-mass of Pallas, every loose block of iron lying on the surface of the ground, nay, even deeply imbedded in it, has generally been declared to be a meteorite, if it only contained a certain percentage of nickel and, which was not always the case, manifested some crystalline texture, called after the discoverer "Widmannstätten's figures." An instance of the value accorded to this percentage of nickel in iron as affording a proof of meteoric origin we

B

have in the iron brought by Sir John Ross from Sowallick (Savilik). For that famous investigator of the polar regions received from the Esquimaux in Melville Bay some knives consisting of a piece of bone, somewhat like a paper knife, in the edge of which a range of small round iron discs were laid into a furrow. The natives said that they found the material of these on a mountain where two large stones were lying, of which one could not be worked with their tools, whereas they could cut the other to pieces, and that from this latter they took out the small round iron balls and beat them flat. This iron contained nickel, and from that time it has been generally stated that the Esquimaux in Melville Bay made use of meteoric iron.

Professor Nordenskiöld, therefore, after searching in vain for such iron at Fortune Bay, on Disco Island, in North Greenland, where the Rudolph iron is thought to have been found, and being led by the natives to Blaafjeld, Uifak,* did not hesitate to declare the iron masses lying there to be meteorites, when convinced that they contained nickel, and showed Widmannstätten's figures, although he found that iron of the same kind was firmly incorporated in the rock on which the blocks were lying.† He very earnestly denied that this discovery might be interpreted as if the iron were of a telluric origin ‡ and accounted for the relation between the firm and the loose iron by the supposition that the fall of the meteor had taken place when the basalt was forming, which is thought to have occurred in the Miocene period.

Dr. Nauckhoff who, in his capacity of geologist, accompanied the expedition sent out by the Swedish Government in 1871 to Greenland in order to bring home the loose iron-masses, did not venture to pronounce any opinion on their origin, particularly because nickel-iron had not yet been seen in any telluric rock.§ By the manner in which he explained the results of some of his analyses, he contributed however to render the question more complicated, as he believed to have found in the basalt, besides the metallic iron, Troilite and dumpling-shaped portions of Eucrite,

* In the literature this place is called Ovifak, but ought without doubt to be written Uifak, as we must suppose it to be connected with "niariak, I, you, shall go outside" (see the Greenland dictionary of Kleinschmidt). With Uivfak, a fern, it has nothing in common.

† Kgl. Sv. Vetensk. Akad. Förh., 1870, p. 1067.

‡ In for instance Quart. Journ. of the Geol. Soc. of London, Vol. XXVIII. page 44; and Post-och Inrikes-Tidningar, 1871, Nos. 255 and 260, and 1872, Nos. 116 and 111.

§ Bihang. t. Kgl. Sv. Vet. Akad. Handl., Vol. I. No. 6, p. 35.

respectively a mineral and a kind of rock especially characteristic of meteorites.

These views were approved of by Nordenskiöld, who now adopted the notion that the meteoric fall had consisted of Eucrite, with balls and grains of metallic iron.*

This view was generally approved of, for instance by Wöhler, Daubrée, and Tschermak;† because it was also to them decisive that metallic nickel-iron had never yet been found in any telluric rock.

On the news of this remarkable discovery Professor Johnstrup, who immediately saw its great importance, obtained, through the instrumentality of our Ministry, the permission of the Swedish Government for a Dane to accompany the above-mentioned expedition in 1871, and by an order of the 4th May of the same year the Ministry for Ecclesiastical Affairs and Public Instruction intrusted me with the performance of this task. Professor Johnstrup, indeed, thought it necessary to examine the facts at the spot itself, before the loose iron blocks were removed, for he considered that these belonged to the rock upon which they were lying, and that, consequently, they were not meteorites. I also came to the conclusion that the manner in which the iron was lying in the basalt allowed but of one explanation, viz. that it belonged to the latter in the same way as every other mineral belongs to the rock in which it has been formed; and that the loose iron-blocks were boulder stones.‡ If this explanation had been applied to any other mineral, nobody, of course, could have had the slightest objection to it, and the question would only have been in what manner the substance had been formed. Now, on the contrary, the fact that the iron-blocks had a shape and a structure corresponding to those of meteorites was regarded as a "proof" that they must have a meteoric origin.

I, however, immediately saw that their shape could be of no moment, and that chemical analysis could not decide the question; for we had, indeed, to deal here with a new telluric mineral, and however much the structure might resemble that of meteoric iron, this circumstance would have no weight; for no one has ventured to maintain that such iron could not be of telluric origin, and this would certainly be the only just foun-

* Post-och Inrikes Tidningar, 1872, No. 111.

† Wöhler, Göttinger gelehrte Anzeigen, 1872. Daubrée, Comptes rendus, LXXIV., LXXV. and LXXXIV. Tschermak, Mineralog. Mittheil., 1874.

‡ Vidensk. Meddelelser fra den Naturh. Forening i Kbhvn, 1875, p. 295, and Min. Magazine, Vol. I. p. 143.

dation for such a "proof." However, as long as the assertion that any "nickeliferous metallic iron, not being an artificial product, must be meteoric iron" remained unshaken, it was impossible to advance the other view, and my efforts were therefore directed to finding such iron at other places in the basalt, and under such circumstances, as would admit of no doubt as to its telluric origin.

When therefore next year Professor Johnstrup obtained a grant for me to return to Greenland in order to follow up this question further, I examined the basalt at as many places as possible, after first visiting Blaafjeld. At first it seemed that I should not succeed. I nowhere found metallic iron in the basalt, and only at one place, at Asuk in Wajgat, did the boulder-stones give signs of it, but I found no iron in them. When coming home, I saw this question before me quite as insoluble as in the preceding year. Then I began the microscopic examination, and in the preparation No. 17 I had the good luck to discover small grains of metallic iron in a basalt of a peculiar aspect from Asuk in Wajgat, of which I, unfortunately, had in a hurry taken but one sample, without much noticing the mode of occurrence. I then examined more than 200 basalt preparations from more than 40 different places in North Greenland; but in no other, the basalt from Blaafjeld of course excepted, could I discover metallic iron, though several of them precipitated copper. The Professor, Dr. Jørgensen; had the kindness to examine the iron-grains from Asuk, and found that they contained traces of nickel and cobalt. Consequently, the aim was nearly reached, for here metallic iron was for the first time discovered in the basalt, the single grains being visible to the naked eye, and containing those elements which were thought to be peculiarly characteristic of meteoric iron. I had also the satisfaction to find that with respect to this discovery, Rammelsberg declared it to be most probable that the iron masses of Nordenskiöld must be considered of telluric origin,* and he adds that the presence of nickel alone will hereafter not be sufficient to stamp a loose iron block as a meteorite.†

One of the few who from the beginning objected to considering the iron masses of Nordenskiöld to be meteorites, Professor Lawrence Smith, in North America, has lately performed a very careful analysis of the rocks and minerals concerned;‡ and after showing the erroneous interpretation of Nauckhoff with respect to the Troilite and Eucrite, which are simply

* Zeitsch. d. deutsch. geolog. Gesellschaft, XXVIII. p. 225.

† Abh. der Akad. d. Wissenschaften zu Berlin, 1879.

‡ Annales de Chimie et de Physique, XVI. 1879.

magnetic pyrites and dolerite, he proves in how many ways Nordenskiöld's iron differs from meteoric iron, its sole claim to be so considered only consisting in its containing nickel; for, he adds: "Il ne faut pas perdre de vue que l'on ne possède pas, jusqu'ici, de fer natif terrestre authentique en masses auxquelles nous puissions comparer les blocs groënlandais; . . . mais, si nous admettons que le fer d'Asuk est d'origine terrestre (et je ne vois pas comment la chose peut être douteuse après la description du gisement donnée par M. Steenstrup), la présence du nickel et du cobalt perd une grande partie de sa signification, car nous avons vu que ce fer en renferme."* Daubrée, too, who, as above said, was at first much inclined to consider the iron masses of Nordenskiöld as meteorites, has, after the publication of this treatise, abandoned his former view.†

At the invitation of Nordenskiöld, Dr. Törnebohm made a microscopic examination of the rocks Dr. Nauckhoff had brought home from Blaafeld,‡ and like Lawrence Smith, he rejected the Troilite and the Eucrite. On the other hand, partly on the basis of the analyses of Nauckhoff, he mentioned a new kind of rock, Anorthitfels, consisting of Anorthite with Graphite and the red-violet mineral which, according to Nauckhoff, is spinel, according to Lawrence Smith, corundum. As to the iron, he only ventures to speak about the iron-grains which are only large enough for a microscopic examination. In his opinion, they appear, together with magnetic pyrites and the mineral that resembles hisingerite, as later interstitial minerals in a large grained basalt, which, on the other hand, together with "Anorthitfels," is found in a breccia-like manner imbedded in the basalt. The small iron grains, he thinks, originate from the circumstance that the basalt, by its eruption, has melted a bituminous rock, containing lime and clayey soil, which by that means has become Anorthitfels, and the bitumen of which has then later on reduced some iron-solution. These iron-grains are consequently of a telluric origin, and though he does not attempt to prove any difference between the iron in these small grains and that in the large masses, he dares not pronounce any judgment about the origin of the latter. Yet he adds: "In dem Laboratorium der Natur dürfte indessen der Unterschied zwischen der Hervorbringung einer Kugel von der Grösse einer Erbse oder einer solchen von zwei oder drei Kubicmeter Inhalt wohl nicht als besonders wesentlich angesehen zu werden brauchen."§

* *Annales de Chimie et de Physique*, XVI., 1879, p. 491.

† *Comptes rendus*, LXXXVII., 1878, Séance du 9 Décembre.

‡ *Bihang. t. Kgl. Sv. Vet. Akad. Handlingar*, Bd. V. No. 10.

§ *Bihang. t. Kgl. Sv. Vet. Akad. Handlingar*, Vol. V. No. 10, p. 17.

As a matter of course I very much wished once more to be able to examine the ferriferous basalt at Asuk, and when the Board for the Geological Examination of Greenland in 1878 gave me the charge of investigating North Greenland, my wish was gratified, though it was only in the summer of 1880 that I arrived at this remote place.

In the autumn of 1879, however, I had made a discovery in connection with this matter, for in an old Greenland grave at Ekaluit, at Ikerasak in Umanaks-Fjord, I found 9 pieces of basalt containing round balls and irregular pieces of metallic iron. These pieces were lying together with knives, similar to those brought home by Ross, as well as with the usual stone tools, for which latter the raw materials were found in pieces of rock-crystal, chalcedony and Lydian-stone, whereas the 9 pieces of basalt with the iron balls were evidently the materials for the bone knives. This iron is soft and keeps well in the air, from which reason it is fit for use in the manner described by Ross. The rock in which the iron appears is a typical, large-grained felspar-basalt, and this discovery has a double significance, firstly, because it is the first time we have seen the material out of which the *Esquimaux* made artificial knives before they got iron from the Europeans, and secondly, because it showed that they have used telluric iron for that purpose, so that the supposition that they used meteoric iron* falls to the ground, for that only depended upon the belief that all metallic nickel-iron had a meteoric origin. It is, therefore, a matter of course that the blocks, from which the material of Ross's knives has been taken, must from this moment, at least until they have been subjected to a more searching examination,† be considered as being more probably telluric than meteoric iron. Furthermore, this discovery also throws a light on Rink's iron from Fiskernæs,‡ and, perhaps, on that brought by Giesecké from Arveprindsens Eiland,§ being, like the former, malleable,

* Ross, *Voyage of Discovery . . . of North-West Passage*, London, 1819, p. 98, and LXXXIX. The *Edinburgh Phil. Journal*, Vol. I., 1819, p. 164. Silliman, *American Journal of Science*, Vol. 42, 1866, p. 249. *Compte rendu du Congrès international d'Anthropologie et d'Archéologie préhistoriques*, Bruxelles, 1872, 6me. Session, p. 242.

† Christian VIII. caused in the years of 1840-50 two expeditions to be equipped for the purpose of looking for these iron masses, one on dog sledges, and one in boats; but no result was obtained, the former only going a few miles from Upernivik, and the latter not even setting out.

‡ Rink got this iron, among other minerals, from a Greenlander. It resembles very much the iron from Ekaluit, and is the same piece which Forchhammer mentions to have received from Motzfeldt. (Lütken Almeent. *Naturskildringer*, I. p. 220, Note.)

§ Of this iron we know nothing but what is written in Giesecké's MS. Catalogue: "Ein zerfressenes Stück (gediegen Eisen?) gefunden in einem Torflager auf Arveprindsens Eiland."

and keeping well in the air. That the iron from Fiskernæs has been found so far from the trap-territory is easily explained in the same way as the pieces of bell-metal which are found along the coast through all North Greenland, that the Esquimaux, on their frequent voyages, have carried it with them, and it may perhaps, like the iron from Ekaluit, at some time or other have come from a grave.

Finally, the iron found at Ekaluit is also of importance from the reason that it affords testimony of the old graves of the Esquimaux being used for the storing of telluric iron. Yet it cannot be of frequent occurrence there, as it would else scarcely have escaped the eyes of the many persons who have sought for antiquities in the graves, however easily it may be disregarded ; - for even I myself, who am so accustomed to look for metallic iron, have only found it in this one grave, though I have examined several hundreds.

Everybody who knows the manner in which the Esquimaux form the names of localities, must see in Ross's name Sowellick (Savilik) an intimation with respect to seeking places where metallic iron is to be found. Thus Kleinschmidt, in his Greenlandish Dictionary, has already mentioned names which allude to it, and, after the discovery at Ekaluit, I do not doubt of success in that direction. I have had myself only an opportunity to make investigations at one of these places, say at Saviorkat, at the post of Niakornak in Umanaks-Fjord ; but the time was so very short, and the weather so unfavourable, a thick fog with showers prevailing during all my stay there, that my search was performed just as if I were blindfolded, therefore the negative result I obtained is of no importance whatever. Although a search in such places might be interesting and, without doubt, also accompanied by success, it is still, after my later discoveries, of less importance, for in the summer of 1880, without this clue, I succeeded in discovering nickel-iron in solid basalt at several places on the coast of Disco. The first of these was Asuk.

As above mentioned, I brought from thence in 1872 the piece of basalt that was found later to contain metallic iron, but without noticing the existence of it, as I had no idea of its importance, and I therefore found it a little difficult to discover the place again. However, I was convinced that if I could discover the place where I then had pitched my tent, I should certainly also find the basalt. I had therefore secured the same coxswain of the woman-boat (*oomiak*) who then accompanied me, for, confiding in the faculty of the Greenlanders to find out localities, I was sure he would be able to recognise the site of my tent. Unfortunately, however, he could not find it again, and therefore brought me to a place six miles too far to the east ; on that account I lost some days in looking for the right place, and having at

last found it, I could scarcely, for want of provisions, remain there for 24 hours. The place is, however, easy to be recognised, being where "Asukhouse" has stood; nay, this house has even been built of the ferriferous basalt, just as the tent walls near Ivigtut were formerly built of cryolite. Fig. 1 shows the stratification here. At the base

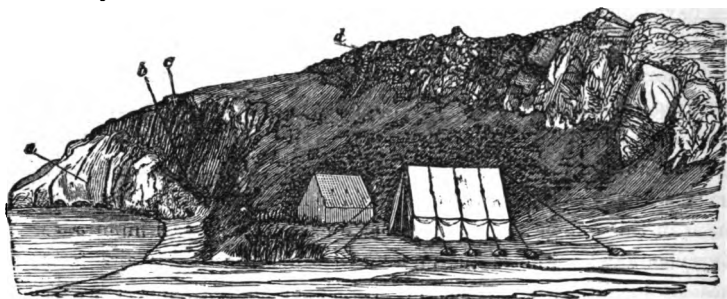


FIG. 1. (R. Hammer.)

at the surface of the water, to the left, are to be seen the coal formations, *a*, in a slope about 20 feet high. Above these is a peculiar mass, *b*, resembling tuff, and consisting of a mixture kneaded together of basalt-tuff and a partly hardened and modified clay-slate containing sand. On this rests a stratum of basalt, about 50 or 60 feet thick, *c*, shaped in magnificent columns, among the finest I ever saw in Greenland, and there-upon follows at last the *ferriferous basalt*, *d* (the bed seen above the tents), with a thickness of about 50 feet. The whole slope is about 120 feet high, and the strata dip about 10 degrees in the direction of the coast towards north-west. The limits towards the columnar-basalt below can easily be seen, as they are very sharp,* but I did not succeed in discovering the upper boundary; the reason of this, however, was certainly only want of time. *This peculiar layer of basalt is filled from top to bottom with iron-grains* of all sizes, from the fraction of a millimeter to a length of 18 mm. with a breadth of 14 mm., which is the greatest I have found. Yet the larger balls do not consist entirely of iron, for they seem to be an aggregate of smaller grains grown together, a section through them reminding one of the structure shown by the Mesosiderites. When polished this iron shows beautiful Widmannstätten figures, which fact, consequently, proves the truth of my supposition set forth in my former paper, that if we succeeded in finding larger blocks of telluric iron, we should also find

* But only seen with the naked eye; for in microscopic preparations, exhibiting both varieties, one sees how the fluctuating structure by which the ferriferous basalt is in so high a degree distinguished, passes into the granular structure of the columnar-basalt and effaces the limit.

these figures in it. In the same paper I directed attention to the occurrence of graphite together with the iron, and this time I found here in the basalt a considerable amount of this mineral as well as of the graphitiferous felspar (the "Anorthitfels" of Törnebohm) found at Blaafjeld. Also in the basalt from Ekaluit there was graphite together with the pure iron.

The next place where I found a solid ferriferous basalt is a neck of land on the northern side of the mouth of Mellemfjord, on the western side of Disco. Already at Napasuligsuak, in the north of Nordfjord, I had found boulder-stones of the basalt, but neither there nor in this whole fjord did I find it *in situ*. The neck of land at Mellemfjord we called "Jernpynten," because it, having a breadth of about the quarter of a Danish mile, proved to consist almost entirely of this rock. Yet this is only true with respect to the extremity of it; for some hundred feet inside we find an ordinary large-grained basalt (Doleritporphyr), and only at a distance of about 4,000 feet we again discovered the upper part of this layer on the slope of the rock in a height of about 540 feet. The lower boundary I could not determine, on account of downfallen masses and of vegetation. This description, however, only refers to the southern side of the neck of land; on the northern side, the large-grained basalt is found quite out to the extremity, but immediately within there the ferriferous basalt stands firmly in a slope about sixty feet high, and also forms a couple of rocks lying a little northward to the isthmus. Seen from the southern side of Mellemfjord the layers in the rocks dip here about eight degrees towards west, which fact also corresponds with the circumstance that after the interruption the ferriferous basalt is only met with at a height of about 550 feet, and that the angle from there to the isthmus was measured to be eight degrees. How great the thickness of the layer is I cannot tell, but I estimate it at about 100 feet. When we walk higher up the slope of the rock that for a part is overgrown, we again meet with it in a height of 950 feet. The angle from here to the isthmus is $9\frac{1}{4}$ degrees. Above, there lies a red amygdaloid, and higher upwards I could not find the layer either *in situ* or in loose pieces.

The ferriferous basalt here resembles generally that from Asuk, as well in hand-pieces as in microscopic preparations, yet at several spots it approaches the appearance of a small-grained basalt. The manner in which the iron appears is quite analogous to that at Asuk; and here too graphite and graphitiferous felspar are to be seen, partly in sharp-edged pieces, partly in concretion-like excretions.

About one and a half Danish miles further up the Mellemfjord, I found near some remnants of a house, in the steep bed of a river, a considerable number of large, sharp-edged blocks of the ferriferous basalt. The stratum to which they belonged I could not find or reach, the bed of the river being yet full of snow and ice; but their being *in situ* is not to be doubted, for the pieces looked as fresh as if they had lately fallen down.

Furthermore, ferriferous basalt is found *in situ* in a ravine on the northern side of the inner part of Mellemfjord, in a height of 800 feet. Here the iron was to be seen partly secreted in the basalt-mass itself, partly filling the cavities of pores in connection with magnetic pyrites. Here too are seen both sharp-edged pieces and concretion-like secretions of graphite and graphitiferous felspar. The basalt is partly as small-grained as at Asuk, partly large-grained, and then is not to be distinguished from the common dolerite. The iron shows on being polished and etched beautiful Widmannstätten figures, and contains, according to an analysis which Professor Dr. J. M. Jørgensen has been kind enough to perform, 2.69 per cent. of nickel. It is soft and malleable, so that it can easily be hammered into plates thin as paper, and shows, like the iron at the above-mentioned places, plane cleavages (after the octahedron?) with a strong tin-white lustre that remains unchanged for months.

Once more I found ferriferous basalt *in situ*, viz. on the southern side of Mellemfjord at Ivigsarkut, where it closely resembles common basalt; it has, however, partly a lava-like aspect.

On the rock in the east thereof, the loose stones, on the slope to a great extent overgrown in a height of about 1,850 feet, also consisted nearly exclusively of ferriferous basalt, so that the layer must there also be firm. As on the northern side of the fjord, the strata dipped about six degrees outward, towards north-west.

Metallic nickel-iron with Widmannstätten figures has now been proved to be also a telluric mineral, and the presence of nickel together with a certain crystalline structure are consequently not sufficient to give the character of meteorites to loose iron-blocks, so that the view put forth by Professor Johnstrup in 1871,* in opposition to the "meteoric iron" of Nordenskiöld, has been proved to be right.

The places where metallic iron is found in North Greenland, the number of which has now been considerably enlarged, are marked on the map† with Fe and (Fe) respectively, when the iron has been found *in situ*

* Communicated in "Vidensk Selskab," the 26th Jan. and 9th Feb., 1872.

† Not given with this Paper.

or only in loose blocks. Without entering upon details with respect to the chemical composition, an account of which will be given in the following treatise by Mr. J. Lorenzen, I shall only here observe that *there seem to be two kinds of iron*, one being hard, brittle, and easily weathered, containing a greater quantity of carbon, which we with Forchhammer may call *meteoric cast iron*, to which belongs the iron from Niakornak, Jacobshavn, Fortune Bay, Blaafjeld, and, perhaps, Arveprindsens Eiland (Heir Apparent Island); and another, *meteoric wrought iron*, being soft, malleable into thin plates, for a greater part resisting the influence of the atmosphere, and only containing a small quantity of carbon, to which belongs the iron from Sowellick (Savilik), Fiskernæs, and all that I have found. The latter kind of iron, which resembles real meteoric iron more than the iron from Blaafjeld does, will undoubtedly prove a curious material for comparison in the study of meteorites, and we shall now see if in a chemical way any difference can be detected between meteoric and telluric nickel-iron.

In my former treatise I tried to maintain that the manner in which the iron appeared in the basalt at Blaafjeld* *could only be explained by its being formed in it*, and this notion has also been fully approved of by Lawrence Smith and partly by Törnebohm, as far as those iron-grains which are not larger than are fit for a microscopic examination. The reason why Dr. Törnebohm does not venture to go further, is evidently the same that made Nauckhoff, Tschermak and Daubrée doubt the telluric origin of the iron-masses of Nordenskiöld—I mean the fact that such iron had not been found elsewhere; but this objection now being removed, I do not doubt that he too will give up his reservation. The peculiar breccia-like structure the basalt has at Blaafjeld *there* where it encloses the iron, caused Nauckhoff to suppose that there were lumps and dumping-like parts of other rocks in a common basalt, but while his description particularly suggested the supposition that these rocks were derived from outside, as also Nordenskiöld has understood it, Törnebohm represented the matter as if a dolerite and his "Anorthitfels" were carried up as fragments with the basalt. I, too, immediately saw this breccia-like structure; but as to the Anorthitfels, I considered it to be porphyritically secreted lumps of a graphitiferous felspar, and the large-grained parts (the dolerite of Törnebohm) I thought to be a variety of the common

* According to Dr. Törnebohm, my notion that the iron is here found in a layer and not in one or two dykes has now been acceded to by Professor Nordenskiöld. L. c. p. 4. See also Nordenskiöld: "Studier och Forsknigar," p. 210.

basalt, which, on account of peculiar circumstances being at work, has got a somewhat different aspect, and has probably also during the formation been subject to great changes of volume that have produced smaller veins. It is moreover difficult to observe matters at the place, partly on account of the quantity of weathered iron crossing the basalt (so that each fragment is surrounded by a coating of rust), and partly on account of the large loose stones covering the shore and thereby preventing a systematical investigation. At any rate, a breccia-like aspect, as well as concretion-like secretions, are no very rare features in the basalt; but expatiating upon this would here lead me too much astray, the more as I hope later to return to this subject in a statement of my researches on the basalt in North Greenland, generally speaking.

When we proceed to examine the relations in which the iron appears at the other places, though they are easier to be overlooked there, because the blocks of iron are smaller, yet, as at Blaafield, we also everywhere meet graphite and magnetic pyrites together with the iron, the graphite being found partly in the basalt as small lumps, partly penetrating a triclinic felspar in connection with the same small red-violet grains as at Blaafield. This felspar appears either as single porphyritically secreted crystals or as concretion-like secretions.

In my first treatise I directed the attention to the fact that the ferri-ferous basalt at Asuk had a peculiar aspect; but it was, however, not my meaning that it should not be considered a basaltic rock, even if it be not a typical basalt. This view has been confirmed by my later discoveries; for however peculiar it may look in general, yet it shows in Mellemfjord *such complete transitions to common basalt* that it is evidently but a variety which we might characterise as *iron-basalt*. The iron appears here in three ways:—(1) partly as small, drop-like particles equally distributed throughout the whole mass, as it is in a typical way at Asuk; (2) partly as sharp-edged grains grown together, with a tin-white lustre at “Jernpynten,” and partly in Mellemfjord; and (3) finally, filling out pores in connection with magnetic pyrites, as in the inner part of Mellemfjord.

Not only is the graphite a steady companion of the iron, but this mineral is also to be found at several places in the basalt where the iron is not visible, at least not to naked eyes, partly as small round balls; thus, in a dyke of basalt at Kook Angnertunek, on the southern side of Upernivik's Island in Umanaksfjord (Fig. 2, p. 18), and in a dyke of basalt at Nuk in Waigat, and partly quite penetrating the basalt, so that we are entitled to speak of a *graphite-basalt*. Such a rock, graphite-basalt, appears in a great bed in the steep inaccessible rocky wall above Nuk,

in Waigat (and there it also contains microscopic iron-grains); furthermore, at Nunnerut, near the coal mine of Ritenbenk; and, judging from the boulder-stones at Asuk, also perhaps at the north-western extremity of Disco; and, finally, it is found *in situ* at Nordfjord.

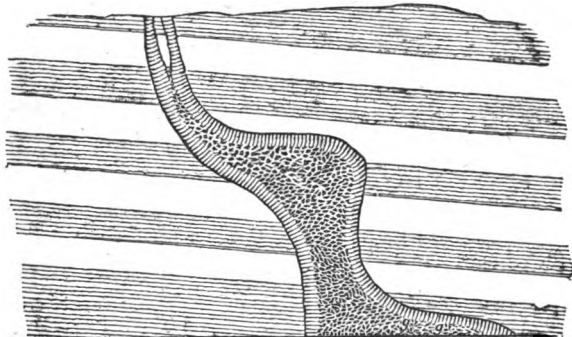


FIG. 2.—Dyke of basalt breaking through the coal-containing formation (slate, the striped compartments and sandstone) at Kook Angnertunek. Towards the side the basalt is separated in columns, and at *g* it contains round lumps of graphite as large as peas.

Here it is to be mentioned, too, that the basalt on the northern side of the large Bay of Kasigisat, between Nord- and Mellemfjord, contains large concretion-like lumps of graphitiferous felspar, much resembling rounded fragments, and, perhaps, also being so.

However there may be a difference between the manner in which the iron appears at Blaafjeld, and that in which the one or the several ferriferous basalt layers appear along the northern and western coast of Disco, wherefore, perhaps, we may be inclined to make the following inference:—

Of course the iron in the basalt layers is telluric, but the large iron-masses at Blaafjeld, which appear only in a much limited region, are, as to their aspect and size, so essentially different therefrom, that we cannot think them formed in the same manner, and so they may, perhaps, be meteoric; however that may be, I must, in the first place, be permitted to refer to the *mass of magnetic pyrites in the dyke of basalt at Igdløkunguak*,* which is quite as large and shows that masses of a similar size can be formed in the basalt, or can, at any rate, be carried up with it; and, in the second place, I must refer to the fact that nickel-iron with Widmannstätten figures now *has been proved to be a telluric mineral*, the want of evidence of this fact, according to Lawrence Smith, being the only ground for considering the iron-masses of Nordenskiöld to be meteorites; for in all other respects real iron meteors were, indeed, very dissimilar from them.

* Vidensk. Meddelelser fra den naturh. Forening i Kbhvn, 1875, p. 304.

II.—*A Chemical Examination of Greenland Telluric Iron.*

By JOH. LORENZEN.*

(Translated from *Meddelelser fra Grönland. Hefte 4. 1883.*)

WHEN in 1870 Nordenskjöld had made the discovery at Blaafjeld (Ovifak) on the Isle of Disco of the remarkable large iron blocks, there soon, as will be remembered, arose a whole literature on the occurrence and origin of this iron. Although the Danish naturalists had, from the first raised a series of objections against the theory of the meteoric origin of these iron-blocks, the problem of their existence could not be satisfactorily solved without careful geological investigations having been first made into the nature of the whole of the Greenland basalt-formation. Such investigations having been made by Mr. K. J. V. Steenstrup, I was directed by the Danish Commission for the Geological and Geographical Survey of Greenland to make a chemical examination of the materials collected. The following is a report of the examination thus undertaken, which, however, was not confined to the rich collection brought home by Mr. Steenstrup, but has been extended to a number of specimens of iron preserved in the Museum of the Copenhagen University. These have been found in Greenland at different times since the beginning of this century, but only a few of them have been hitherto accurately described, although they may, most of them, have been mentioned, incidentally at least, in some work or another. With the specimens in question so many problems are connected, that I have thought it proper to confine—previously at least—the object of my examination to the two most interesting ones. The first question which arises is that of the native iron itself, and also to a certain extent that of the basaltic rock. The second question concerns the graphitic felspar, the “Anorthitfels” of Dr. Törnebohm,† which constantly occurs with the iron. I have not examined the pyrrhotite and the chlorophæite, these being of less interest. As long as the point of issue was the possibility of the iron being meteoric, the occurrence of the pyrrhotite was more important than it is now, especially because it was taken for Troilite, owing to an incomplete analysis made by

* Dr. Lorenzen died on the way to Greenland, the 5th May, 1884.

† *Bihang t. Svenska Vet. Akad. Handl.*, Vol. 5, 1878, No. 10, p. 14.

Dr. Nauckhoff.* Now, however, as Mr. Steenstrup† and later on Prof. Lawrence Smith‡ have proved the accordance between the pyrrhotite of Blaafield and that of Igdløkunguak, and as the telluric origin of the iron has been indisputably established, this matter is placed more in the background.

Before proceeding to the detailed description of the iron, I shall make some remarks with regard to the manner in which the analyses have been made.

As a rule the iron was dissolved in hydrochloric acid, in some few cases in *aqua regia*. The solution evaporated, the dry residue was dissolved as usual by means of a little diluted hydrochloric acid. In the solution the copper was first determined; then the iron was separated from nickel and cobalt by ammonium carbonate after the method of Lippert, as given both in Rose's and in Fresenius's works on quantitative analysis. If only so much ammonium carbonate be added, that a little iron is still in the solution after precipitation, this method is very excellent. The small amount of iron remaining was precipitated by ammonia in excess and added to the first precipitate. This operation was repeated several times in order to extract all the nickel and cobalt, but experience shows that in most cases two precipitations, if well made, would have been sufficient. In the two first analyses the nickel and cobalt were weighed in the form of metals, in the others in the form of sulphates. When dissolved, the iron always left a residue, which naturally was a little attacked by the acid, and it must therefore be expected that a little alumina, iron-oxide, lime, magnesia and silica, perhaps also alkalis, would be found in the solution. As none of these substances has anything to do with the composition of the iron, I have not determined any of them but the silica and alumina. It also ought to be remembered, that the quantity in which they are present in the solution depends upon quite casual circumstances, such as this, whether a more or less diluted acid be used, &c. Moreover, it would have been very troublesome to determine the lime and the magnesia on account of the large amount of salts of ammonia which by applying the above method had been accumulated in the solution.

Phosphorus was searched for in all the analyses, by applying the method described in Fresenius's Quantitative Analysis, 6th edition, II. p. 494. As Dr. Törnebohm by means of a combined microscopical and chemical investigation has found Schreibersite in the Blaafield iron, I was rather as-

* Bihang t. Svenska Vet. Akad. Handl. Vol. I. 1872, No. 6.

† Videnskabelige Meddelelser fra naturhistorisk Forening i Kjöbenhavn 1875, 284.

‡ Ann. de Chimie et de Physique, 5te série, t. XVI. 1879, pp. 452-505.

tonished at not being able to detect any trace of phosphorus in any one of the specimens analysed, except in the Niakornak iron, where its presence had already been stated by Forchhammer and Lawrence Smith. It ought, however, to be remembered, that the amount of the other constituents of the iron-pieces is somewhat varying. In searching for the phosphorus, as a rule, I used 5 to 6 grs. of the iron.

Sulphur was determined by dissolving the iron in *aqua regia*, and evaporating to dryness, whereupon the residue was dissolved in a little hydrochloric acid, and the sulphuric acid precipitated by barium-chloride.*

Carbon was determined by the method of Ullgren (described both in Fresenius and in Rose); the iron was dissolved in sulphate of copper, and the remaining carbon was oxidised by chromic and sulphuric acid, and weighed as carbonic acid.

Chlorine was not determined, although present in small quantities in all the iron specimens, as appears from the iron chloride oozing out on almost every piece of iron. But this examination would form a part of an investigation of all the soluble salts contained in the iron, which my time has not yet permitted me to undertake.

I have not examined iron from all the new localities, but only from those that are somewhat abundantly represented in the Copenhagen museum. The following account first describes the iron from the chief locality, Blaafjeld (Ovifak, or more correctly Uifak); then that found in three other localities on Disco island, viz. at two different places in the Mellemfjord on the west side—and at Asuk in the northern part of the island, which latter place has obtained a peculiar interest, as it was the first place after Blaafjeld where Mr. Steenstrup succeeded in finding iron *in situ*. Then follows the description of the loose blocks, all of which have, with perhaps one exception, been imbedded in the basalt; and of the remarkable iron taken from the Greenland grave at Ekaluit. To the examination of the last is added an analysis of Greenland wrought iron, viz. two knives, the material for which must have been taken from the basalt.

Lastly follows an examination of the *graphitic felspar*, taken from two of the many localities.

I. IRON IN SITU.

A. BLAAFJELD. (OVIFAK=UIFAK.)

Under this heading I also include the loose blocks which have been found on the shore at "the iron locality," because they also have once been

* Rose. Handbuch d. Anal. Chemie. II. p. 563.

imbedded in the basalt. It is well known that investigations have been made with regard to this iron by many chemists, as Nordenskjöld, Nordström, Nauckhoff, Wöhler, Daubrée, and Lawrence Smith, all of whom have given their opinions on the now settled question of its telluric or cosmical origin.*

Several of these investigators have attempted to make out different types of iron, which at the first sight seems very natural, but further examination shows that nearly every new piece of iron may be taken for a new type. If the types which the different investigators have set up be compared, the identification of them also will be found a very troublesome work. Really all transitions may be found. As an instance of this, may be mentioned that metallic iron is found in the form of small grains imbedded in common dolerite, and that grains similar to these are also found imbedded in a soft green mass, which latter is found in some of the blocks lying on the shore. A fresh fracture of this rock affords an exceedingly beautiful aspect, when the silver-white shining iron grains are seen disseminated in the fine green ground-mass. This aspect, however, lasts only a short time; after a few minutes the grains become already somewhat dim, and after some days we see only a spotted grey-brown mass with a few metallic points. These latter are more durable; some fragments of the rock in question were kept in a closed glass for more than half a year, together with a small cup filled with concentrated sulphuric acid, and at the end of this time the metallic points still retained their original appearance. While in the cases just mentioned, the dolerite or the green ground-mass was absolutely predominant, we, on the other hand, find other specimens in which the iron and the basalt are almost equally developed, or where the iron is beginning to prevail. The analyses given under No. 8 were made on fragments taken from such a block. Before the block was broken to pieces, it looked very firm and strong, but nevertheless it was very easily crushed with the hammer. It appeared that the interior was composed of a soft mass, which when pulverised and sifted, might be separated tolerably well into grains of iron and a brown powder, which latter evidently owed its origin to decomposition. The grains of iron could not be further powdered, and were a little malleable. On the outside, the loose mass was encompassed by a firm crust, intermixed with basalt. I think that

* Since the above lines were written in Danish, a new paper by Nordenskjöld has appeared, wherein this matter is discussed from quite a new point of view, the correctness of which, however, the author cannot admit; but it would take too much space to enter on a further discussion of it here.

some of the bigger blocks are of this kind, as both Daubrée and Lawrence Smith state that the blocks examined by them when sawn through were found to consist of a firm crust around a loose interior. Further, a whole series of transitions are found between these blocks, and those specimens which consist almost entirely of metallic nickel-iron. Of these last No. 1 and partially No. 2 below are examples. It is true that such hard, firm and tough masses of iron present an appearance quite different from that of the grains that are found in the manner above described, disseminated in the basalt, or in the remarkable green ground-mass. But in fact a difference between the two is to be found only in the amount of the iron present. It appears as if the iron had originally been deposited at many points, and being still in a fluid state had in some places accumulated to form greater masses. It is an interesting fact that both malleable and cast iron has been produced; at Blaafjeld both forms occur, while at the other localities only the malleable iron is found. I have not analysed the Blaafjeld malleable iron, but Mr. L. Smith has made an analysis of the same,* the result of which agrees very well with one of the varieties examined below. No. 1 again, as well as several specimens that have on former occasions been examined by others, belongs to the form which may be considered as natural cast iron.

As is well known, there is still a peculiarity on which a distinction might be founded, I mean the aptitude so characteristic of many specimens of this iron to crumble when preserved in a museum, while it stands the open air much better. As a contrast to these might be set up some other specimens, for instance No. 1, and some parts of No. 2 below, which consist almost entirely of metallic iron, and may be preserved in a museum without the interior of the same being damaged. Further also, the grains mentioned above that are found imbedded in the basalt do not seem to lose any of their original fresh lustre.

No. 1.—A piece of iron of the size of a large fist, oblong, flat on one side, and round on the other side. Fracture granular, silver-white when quite fresh. The iron very hard and tough; cannot be crushed with a common hammer, but only with a steam hammer. Very difficult to bore even with the hardest tools. On the whole very pure, only in a few places enclosing some of the rock. No difference between the exterior and interior parts; the boring was done in the interior. The iron excellently durable. It had been lying for a long time on a flat roof exposed to rain and sunshine, and after having been broken to pieces, it has been

* l. c. p. 465.

kept in the dry air of the museum, without suffering any damage under these very different conditions.

The specific gravity of a small piece weighing 2·6185 grs. was 6·87 at 20° C. The chief analysis was made on 2·471 grs.

Results of the analysis :

Cu ...	...	...	...	0·16
Fe ...	...	...	...	91·71
Ni ...	...	...	...	1·74
Co ...	...	...	...	0·58
S ...	...	...	...	0·10
C ...	...	...	...	1·87
SiO ₂ ...	...	...	...	0·81
Al ₂ O ₃ ...	...	...	...	1·21
Insol. in HCl	...	...	...	2·89

99·52

Phosphorus could not be traced in 6½ grs. of iron. The determination of carbon is the mean of two analyses, which gave 1·85 and 1·88 respectively.

No. 2.—A flat slab, which when broken to pieces showed in some parts a similar green mass to that mentioned above, but in other places pure, silver-white iron, with foliated fracture, and fine cleavage faces. This piece had formerly resisted the influence of the weather in the open air very well, but is now partially altered on account of its being preserved in the museum. The parts consisting of pure iron are those best able to resist, and these show on fresh fractures the fine silver-white lustre.

Composition of the iron :

Cu ...	...	...	...	0·16
Fe ...	...	...	...	91·17
Ni ...	...	...	...	1·82
Co ...	...	...	...	0·51
S ...	...	...	...	0·78
C ...	...	...	...	1·70
SiO ₂ ...	...	...	...	0·46
Al ₂ O ₃ ...	...	...	...	2·12
Insol. in HCl	...	...	...	0·77

99·49

The chief analysis was made on 2.716 grs. Phosphorus not traced in $5\frac{1}{2}$ grs. The determination of carbon is the mean of two, giving 1.62 and 1.78 % respectively. The great percentage of sulphur is striking as well as the large amount of dissolved alumina, while the undissolved residue is insignificant. This shows that the rock had been easily decomposed by the acids used.

No. 8.—The worn specimen mentioned above. One analysis was made on the altered interior (I.), another on the fresh exterior parts (II.). In both cases the metallic parts were tolerably well separated from the non-metallic ones. This was best effected by pulverising and sifting, on the altered interior parts. It was not possible to undertake a further separation by a magnet. To separate oxide of iron from metallic iron in the analysis seemed of no use, as the alteration had only reached a certain point, and an analysis made to-day might have given quite another result than one made a year afterwards. Because of the method also by which the iron grains had been isolated, the proportion found would have been quite arbitrary. Thus part of the metallic iron stated in the analysis must be taken to have been in reality in the state of oxide.

Composition of the iron :					I.	II.
Cu	...	...	...	...	0.19	0.28
Fe	...	...	...	...	82.02	59.77
Ni	...	...	...	...	1.39	1.60
Co	...	...	...	...	0.76	0.39
S	...	...	...	...	0.08	?
C	...	...	...	...	1.27	1.20
SiO ₂	...	...	...	...	0.59	0.39
Al ₂ O ₃	...	...	...	...	1.08	3.79
Insol. in HCl	...	...	...	...	8.08	22.28

The chief analysis was made on 2.589 grs. (I.), and 2.5705 grs. (II.).

The determination of carbon is the mean of two, giving 1.24 and 1.31 respectively. In the same analysis phosphorus was not traced in $5\frac{1}{2}$ grs. In the second analysis made, phosphorus and sulphur were not searched for. As I obtained a much larger residue than I had expected in II., I determined the amount of silica therein, which was found to be 59.61 per cent. When the purity of the silica was tested, it appeared that it contained a small quantity of other elements. When it is taken into consideration that part of the alumina had been dissolved, it appears that the rock itself must have been considerably attacked by the acid, and the high percentage of silica cannot then be cited as an objection to the conjecture that the rock is a common basalt.

B. THE MELLEMFJORD.

A. *The Interior Parts of the Fjord.*

I have examined the iron as well as the basalt from this new locality.

This Iron like that next to be described is malleable, and all these specimens of iron present great similarity to each other. It is found in round and oblong grains usually of the size of a pea or a little larger. The larger grains often consist of smaller ones, which are welded together, as is very easily detected by hammering the grains flat. When the basalt is hammered, two or more pieces may often be kept together by the tough flexible iron. The iron is silver-white, very soft, and may in consequence of its extraordinary malleability be hammered into very thin plates, which very easily preserve impressions of the hammer and anvil. When hammering the grains I always saw small pieces of basalt falling out, which had been imbedded between the grains or in their cavities. The specific gravity therefore ought only to be determined on a flat and well-hammered plate; the grain before being hammered will always, even if the surface be filed quite shining, give too low a specific gravity. Mr. Steenstrup and I made the following experiments: a grain weighing 1.0045 showed a specific gravity 5.84, another one weighing 0.8885 gave 7.80. The first when hammered lost a considerable quantity of basalt, and this explained the low specific gravity. When the other grain was hammered, its specific gravity rose to 7.92. A third specimen equally hammered weighing 1.4955 grs. showed a specific gravity of 7.48. The high specific gravity depends upon the small quantity of the carbon contained therein, which circumstance also accounts for the iron being so malleable; and upon the small contents of nickel and cobalt.

I searched for phosphorus and sulphur in the same analysis in 4 grs. by the method given in Rose's Handbuch and Anal. Chemie. II. p. 508, but I was not able to detect any phosphorus. The chief analysis was made on 2.164 grs. Results of the analysis:

Cu	...	...	...	...	0.38
Fe	...	...	...	...	93.89
Ni	...	...	...	...	2.55
Co	...	...	...	...	0.54
S	..	...	...	...	0.20
C	...	...	...	...	0.28
SiO ₂	...	...	...	...	0.46
Insol. in HCl.	...	...	...	...	1.48
					99.73

The Basalt.—From this place Mr. Steenstrup brought home iron that had been taken partly *in situ*, partly from loose blocks. The basalt found *in situ* is compact, and reminds one very much of the basalt of Asuk or that of the Jernpynt in the Mellemfjord. The loose blocks consist of medium grained dolerite. It is very interesting, that although we may find iron-grains of the size of a pea in the compact basalt, we also find much smaller grains, but in the dolerite large iron-grains only are found.* As the latter afforded more facility for separating the iron from the basalt, I chose the dolerite for the analysis, the results of which follow :—

SiO ₂ ...	...	...	...	58·01
Al ₂ O ₃ ...	...	...	...	15·85
FeO ...	...	...	...	11·58
CaO ...	...	...	...	8·72
MgO ...	...	...	...	7·51
Na ₂ O ...	...	...	...	4·49
				101·11

Some traces of manganous oxide and potash. The iron is given only as ferrous oxide, the two oxides not having been separated. Thus we have here a basalt with a percentage of silica a little higher than usual; but, apart from this, it does not present any difference from common basalt.

B. The Jernpynt in the Mellemfjord.

This occurrence shows a great resemblance with that at Asuk, as did also that last mentioned from the interior parts of the fjord. The basalt here is sometimes spotted in a similar way to that of Asuk, but it may also occur in the form of a fine-grained dolerite. What has been said on the manner in which the iron-grains are imbedded in the basalt found in the interior parts of the fjord, holds good here also. Still the iron is not so white and not quite so soft and malleable, on account of the larger amount of carbon contained therein. For the same reason, perhaps, the specific gravity also is a little lower. In one specimen of hammered iron weighing 0·9625 grs. I found the specific gravity 6·90 at 14°C., in another, weighing 1 gr., 7·57 at 14° C.

Results of the analysis :

Cu ...	...	...	...	0·48
Fe ...	...	...	...	92·41
				92·89
Carried forward				...

* For this observation I am indebted to Mr. Steenstrup.

	Brought forward				92.89
Ni	...	...	...	...	0.45
Co	...	...	...	...	0.18
S	...	...	...	...	Trace.
C	...	...	...	...	0.87
SiO ₂	...	...	...	...	0.90
Al ₂ O ₃	...	...	...	...	0.60
Insol. in HCl.	...	...	...	...	4.57
					100.46

Phosphorus and sulphur were searched for in the same manner as in the case of the iron from the interior parts of the fjord. The chief analysis was made on 1.674 grs. The determination of carbon is the mean of two giving 1.08 and 0.72 per cent. respectively. The materials were here separately selected for each determination of carbon. It is interesting to see how, with regard to the percentage of nickel, this iron makes a transition to the Asuk iron.

C. Asuk.

This was the first place after Blaafjeld where Mr. Steenstrup found iron *in situ*, and the locality has a peculiar interest, as it appears herefrom to be the most probable theory that all the "basaltic" iron had a telluric origin.* The iron found there was disseminated throughout the basalt in the shape of very fine specks, which could only be isolated by means of a magnet, after a very careful pulverisation. In the specimens, brought home later on, there are bigger grains, some of which attain the size of a hazel-nut. Yet most of them are rather small, smaller than those from the other localities, and if a biggish one is hammered one feels somewhat disappointed, seeing that a large part of it is the basalt, lying between iron grains, while the latter look as if they were welded together. The iron is silver-white, very soft and malleable; some hammered grains weighing 1.056 grs. afforded the specific gravity 7.26 at 12° C.

When crushing the basalt I collected some bigger and smaller grains, which were used for the analysis. As it was difficult to get much material, I did not determine the sulphur. The iron was dissolved in *aqua regia*, and phosphorus was searched for in this solution, but none was found.

* I. c., 1875, p. 296.

Results of the analysis :

Cu	...	...	...	0.14
Fe	...	...	...	95.15
Ni	...	...	...	0.84
Co	...	...	...	0.06
C	...	...	...	0.96
SiO ₂	...	...	...	0.68
Al ₂ O ₃ ...	...	...	...	0.51
Insol.	...	...	...	1.90
				—
				99.74
				—

Of all the iron found *in situ* or in loose blocks, this shows the lowest percentage of nickel and cobalt. Yet one of the Greenland knives mentioned below contains a still less amount than this. And at any rate we see that we ought to be very cautious in using the percentage of nickel and cobalt for determining whether loose blocks or Greenland iron tools are of "basaltic" origin or not; for if the proportion can be so low as we have here, we fail to see why it might not be still lower, or why nickel and cobalt might not perhaps be quite absent.

I have not examined the iron taken *in situ* from other localities, the material being so scanty that nothing could be spared for analyses.

II. LOOSE BLOCKS.

A. ARVEPRINDSENS EILAND.*

While the pieces of iron brought home in the beginning of this century by Ross and Sabine have been often mentioned, it has been less generally known that Giesecké also about the same time found a piece of iron much farther to the south, in Greenland proper. As he does not mention it in his Diary, we only have a slight evidence of this fact in the Catalogue of his collection; where this specimen, which is now in the Copenhagen museum, is said to have been found in a bog on Arveprindsens Eiland. The specimen has a peculiar appearance, showing on its surface impressions such as might be made with fingers in a soft mass. The weight is 410 grs. From this piece two small pieces were sawn off, one for the chemical analysis, and another for polishing and etching. The latter did not give the usual Widmanstätten figures, but only indistinct, shining, silver-white figures in the greyish-white ground-mass.

* Means, Heir Apparent Island.

The iron was very tough and hard. An exterior crust of malleable iron was distinguished from the interior part, which latter the hammer only crushed without beating it flat. On account of the failure of one analysis, the carbon was determined from the interior, while the other elements were determined on small hammered plates.

The chief analysis was made on 2·850 grs.

Results :

Cu	...	...	...	0·06
Fe	...	...	...	95·67
Co	...	...	...	trace?
S	...	...	...	0·09
C	...	...	...	1·94
SiO ₂	...	...	...	1·40
Insol.	...	...	..	1·09

100·25

I obtained a very small precipitate in the filtrate from the iron when sulphuretted hydrogen had been added and the solution had been neutralised. As the quantity was too small to be weighed, it was only examined before the blow-pipe with salt of phosphorus. The bead was blue as well in the interior as in the exterior part of the flame, and thus cobalt ought to be present. Whence has this come? It has been proved that extraordinary small quantities of cobalt and nickel may be present in many sorts of iron used for practical purposes,* and a European origin might therefore be suspected in the case of this iron. But the considerations set forth above in mentioning the Asuk iron, show that a Greenland and basaltic origin is also possible.

If a piece of rock had been adhering to the iron the question would easily have been solved, but I have not been able to find any.

B. NIAKORNAK.

Of all loose blocks consisting of so-called "meteoric iron," a block from this place which is now in the Copenhagen museum is the best known, as it has been examined both by Forchhammer† and by Lawrence Smith.‡ The Copenhagen museum received it from Dr. Rink, who on his travels in North Greenland, 1848-50, got it from a Greenlander in an Esquimaux

* Weiske. Ueber den Kobalt u. Nickelgehalt des Eisens. (Journ. f. praktische Chemie. 1866, p. 479.

† Oversigt over det kgl. danske Videnskabskabernes Selskabs Forhandling, 1854, p. 1.

‡ l. c. p. 489.

hut between Jakobshavn and Ritenbenk. This man had found it near the shore on a plain covered with pebbles, through which the Anontok river discharges itself into the sea. Climatic difficulties, viz. snow in winter and floods in summer, prevented Dr. Rink from more closely exploring this plain.

Dr. Rink found the specific gravity of the whole piece = 7.00, and that of some small fragments = 7.02. Forchhammer found also for some small fragments, Sp. gr. = 7.078 at 15° C. Lawrence Smith found for the pulverised iron 7.60, and an experiment made on a fragment weighing 2.7875 grs. afforded me 7.29.

The iron is very hard, shows granular fracture and sometimes small cleavage faces. When etched it shows small irregular Widmanstätten figures. Original weight 10½ kilogram. The analyses of Forchhammer (II.) and Lawrence Smith (III.) are given for use of comparison with mine (I.).

				I.	II.	III.
Cu	...	...	...	0.16	0.45	0.18
Fe	...	...	...	92.46	93.39	92.45
Ni	...	...	...	1.92	1.56	2.88
Co	...	...	...	0.93	0.25	0.43
P*	...	...	...	0.07	0.18	0.24
S	...	...	...	0.59	0.67	1.25
C	...	...	...	3.11	1.69	1.74
SiO ₂	...	...	...	0.24	0.38	1.31
Insol.	...	...	...	1.09	—	—
				100.57	98.57	100.48

It will be seen that the analyses do not fully agree with each other, the reason of which is, I presume, that the iron is not quite homogeneous in all its parts. The same thing may be said for the residue; it is also shown by the varying specific gravity. The determination of carbon is a mean of two, giving 3.02 and 3.20 per cent. respectively. The result of two other experiments, when the carbon was burnt in oxygen, was a little lower, viz. 2.64 and 2.83 per cent. Among the specimens from Blaafjeld similar hard varieties rich in carbon are found, and as it cannot be doubted that the iron has been once imbedded in basalt, it is very possible that it may have been taken by the Greenlanders from Blaafjeld and have been brought by them to this spot. We notice here also on fresh fractures the usual exudations of chloride of iron.

* I am indebted to the kindness of Mr. O. Christensen for the determination of phosphorus in my analysis of this specimen.

Forchhammer mentions "that in one place traces were seen of an earthy mineral, but it could not be determined whether it originated from the trap-pebbles of the plain and had been cemented to the iron by rust, or whether it ought to be considered as the remains of a stony mass which had once surrounded the iron." Perhaps there was not enough for an analysis, and microscopical investigation was not at that time sufficiently advanced to decide such a question. Even now I found a trace of a crystalline mass, but on an attempt to grind it, the whole was crushed to dust. Probably it was a bit of basalt.

C. FORTUNE BAY.

In 1852 a block weighing 11844 grs. was found at Fortune Bay on Disco by the physician Rudolph, and sent to the Copenhagen Museum. Forchhammer has only given two small communications about it, without giving an analysis. He promised a further communication, but must have been hindered from fulfilling this promise, as no such account has ever appeared.

Originally it was very difficult to sever a piece from the whole block, but the smaller pieces themselves are now easily crushed under the hammer; by crushing them we get partly a coarser powder, consisting of small angular fragments of a colour like that of pyrrhotine, and partly of a finer and more brittle powder. Still the iron has nothing to do with pyrrhotine; it contains only a very insignificant amount of sulphur, and gives, when dissolved in hydrochloric acid, only a very slight odour of sulphuretted hydrogen. Polishing and etching afford some indistinct figures.

The chief analysis was made on 2.4005 grs. Phosphorus not traced in $6\frac{1}{2}$ grs. Specific gravity determined on a fragment weighing 5.6054 grs. and found to be 7.19 at $16\frac{1}{2}^{\circ}$ C. The determination of carbon is a mean of two giving 2.38 and 2.41 per cent. respectively. On fresh fractures the usual exudation of iron chloride was remarked.

Results of the analysis :

Cu	...	...	...	...	0.20
Fe	...	...	...	...	92.68
Ni	...	...	...	...	2.54
Co	..	...	...	...	0.58
S	...	...	...	...	0.01
C	...	...	...	...	2.40
SiO ₂	...	...	...	...	0.81
Insol.	...	...	...	...	0.08

98.80

The analyses show a perfect conformity between the Niakornak and the Fortune Bay iron. As to the latter, the locality itself on the Disco coast, not far from Blaafjeld, makes it highly probable that the iron originated from this locality.

No fragments of adhering basalt could be detected.

D. FISKERNES.

While the Niakornak, Fortune Bay and Jakobshavn* iron, perhaps also Giesecké's iron from Arveprindsens Eiland, are very naturally grouped around the basalt formation of North Greenland, this occurrence at first sight seems somewhat more inexplicable, the locality being more than 700 miles distant from the basalt. Our museum received it in 1853 from Dr. Rink, who had obtained it from Mr. Matzfeldt. It has been mentioned, but not closely examined by Forchhammer; and yet this iron, which is very similar to that found at Ekaluit, is undoubtedly the most interesting of all the loose blocks. Forchhammer himself makes the remark, that several circumstances make its meteoric origin very uncertain. The iron in question now consists of two small fragments, weighing 153 grs. Really it is a dolerite, through which the metallic iron ramifies in such a manner, that if we grind a plate of it we see the dolerite and the iron alternating with each other. I therefore give an analysis of both below.

The iron is very malleable, whereby it is distinguished from the other loose blocks, except the outer parts of Giesecké's iron. The specific gravity of some small hammered plates, weighing together 0.960 gr., was 7.06. In the chief analysis, which was undertaken upon 1.962 grs., the iron was dissolved in *aqua regia*, and phosphorus could not be detected in this solution. I did not search for sulphur, in order that I might not use too much of the iron.

Results of the analysis :

Cu	..	..	..	..	0.36
Fe	..	..	..	..	92.28
Ni	..	..	..	..	2.73
Co	..	..	..	..	0.84
C	..	..	..	..	0.20
SiO ₂	..	..	..	..	0.64
Al ₂ O ₃	..	..	..	..	0.64
Insol.	..	..	..	..	1.99

99.68

* On Nordenskjöld's Greenland expedition 1870, Dr. Öberg received this specimen from Dr. Pfaff in Jakobshavn. (Svenska Vetenskaps Akademiens Förhandlingar, 1870, p. 1069.)

The Dolerite.—Mr. Steenstrup has kindly communicated to me the following results of a microscopical examination: "In a section of eighteen square millimetres of the rock accompanying the Fiskernæs iron, I saw a fine grained ground-mass nearly without 'basis,' consisting of small crystals of a triclinic felspar, surrounded by rounded grains of pyroxene, olivine, and ramified particles of magnetite and titanite iron. The mean size of these small crystals is up to 0.3 mm. Seven larger crystals of a triclinic felspar up to 1.5 mm. in length, are disseminated in the ground-mass, the small crystals of which have been arranged around the larger ones. The whole section as well as the single small crystals appear very fresh, and the rock is not to be distinguished from a common coarse-grained basalt from North Greenland, whence it probably originates."

The analysis agrees with the microscopical examination. This was made only by decomposition with carbonate of soda, so that the alkalis were not determined:—

SiO ₂	...	...	...	50.64
Al ₂ O ₃	...	...	...	15.98
FeO	...	...	...	14.92
CaO	...	...	...	9.89
MgO	...	...	...	5.14

It will be seen that the composition is also that of a common basalt, and after all there can be no doubt as to the original locality of the iron. It is easy to understand why it should be carried so far off when we remember that it is malleable. Now that Steenstrup has found iron in a grave in Greenland, we know how much the Greenlanders value this metal, and can understand how such a piece might be carried so far by the hand of man.

E. EKALUIT.

It has long been known by the discoveries of Ross and Sabine that the Greenlanders possessed tools, especially knives, of hammered iron, but it is only by the recent investigations of Steenstrup that it has been ascertained where the natives have obtained this iron, for in a Greenland grave at Ekaluit in the Umanakfjord, he found nine pieces of basalt, wherein were contained grains of metallic iron. Really no difference could be detected between the manner in which the iron is imbedded in the basalt and the way in which the iron is found *in situ* in other places.

The analysis was made on 1.562 grs. On account of the small quantity of material, phosphorus, sulphur, and carbon, were not searched for. A small amount of the latter element must be present, as I remarked a faint

evolution of carburetted hydrogen, when dissolving the iron in hydrochloric acid.

Results of the analysis :

Cu	...	...	...	...	0.23
Fe	...	...	...	...	94.11
Ni	...	...	...	...	2.85
Co	...	...	...	...	1.07
Insol.	...	...	...	...	0.61

98.87

The iron is malleable, and the grains may easily be hammered out to small plates about half an inch in diameter. Prof. Japetus Steenstrup some years ago described some Greenland knives,* the edge of which consisted of a row of such small iron plates. They were placed in a groove in a piece of bone, the one end of the latter being used as a handle. Prof. Johnstrup found in one of the small plates as much as three per cent. of nickel. We now plainly perceive the succession; first the iron *in situ*; then in smaller detached pieces of basalt, which the Greenlanders put in the graves with the dead,—a distinct proof of the value attributed by them to these small pieces of iron;—and finally, we see the tool itself with the wrought-iron: and the way of working it was simply by hammering it flat.

F. GREENLAND KNIVES.

The knives here examined are of another type than those above mentioned, and far more similar to knives of European workmanship. A largish piece of iron is hammered out to a common knife blade, and fitted into a bone handle. Evidently the Greenlanders must have had larger grains in this case than in the case of the knife of the first type; and as it presented a great deal of interest to know whether Greenland malleable iron of such a size might really be procured, I gladly complied with a request of Prof. Japetus Steenstrup, to make these knives also the object of a chemical examination, the more so as I obtained thereby a very interesting addition to my materials.

The first knife had been found on "Hundeeiland" (Dog Island), between Disco and Egedesminde; the other one at Sermermiut, close to Jakobshavn. Only copper, nickel and cobalt were determined.

* Japetus Steenstrup, Sur l'emploi du fer météorique par les Esquimaux de Greenland. (Compte-rendu du congrès international d'anthropol. et d'archiol. préhist. Bruxelles, 1872.)

Results :

			I.	II.
Cu	...	...	0.18	Trace.
Ni	...	...	} 0.23	7.76
Co	...	...		0.56

Both knives were a little more than two inches in length, and consisted of silver-white iron, upon which an etching had been made before I received them, and had produced fine, winding, elevated lines. The second knife (II.) was in some places covered by a wax-like, greenish mass, the colour of which undoubtedly was due to oxidised nickel. For the analysis 1.189 grs. were used in I., in II. 2.949 grs. The whole knife I. weighed 8.1 grs., and the whole knife II. 6.1 grs. In I. was found a distinct trace of cobalt together with a predominant amount of nickel.

It was the more interesting to examine these two pieces of iron, as I thereby had the limits for the percentages of nickel extended. In I. we find the whole percentage of nickel and cobalt 0.23—less than in the iron from Asuk, where it reached 0.40 per cent. This is thus the smallest amount found, if Giesecke's iron is excepted. In II. the joint amount of nickel and cobalt was 8.32, a figure that surpasses by one per cent. the highest percentage hitherto found, viz. 6.50 per cent. Ni and 0.79 per cent. Co, the amount found by L. Smith in a piece of iron from Blaafield.

I first examined the knife I., and the small percentage of nickel found therein naturally raised the question whether this iron might really originate from the basalt, although the amount of nickel found in artificially produced iron is exceedingly insignificant, even as compared herewith.* It was very fortunate that in the knife II. such a large amount of nickel was found, as the question of the origin of the iron of this knife is thereby indisputably decided.

SUMMARY OF ANALYSES OF THE GREENLAND TELLURIC IRON.

	Blaafjeld (Ovifak), Disco.				Mellemtfjord, Disco.		Asuk, Disco.
Cu	0.16	0.16	0.19	0.23	0.33	0.48	• 0.14
Fe	91.71	91.17	82.02	59.77	93.89	92.41	95.15
Ni	1.74	1.82	1.39	1.60	2.55	0.45	0.34
Co	0.53	0.51	0.76	0.39	0.54	0.18	0.06
S	0.10	0.78	0.08	?	0.20	trace	?
C	1.37	1.70	1.27	1.20	0.28	0.87	0.96
SiO ₂	0.31	0.46	0.59	0.39	0.46	0.90	0.68
Al ₂ O ₃	1.21	2.12	1.08	3.79	—	0.60	0.31
Insol. ...	2.39	0.77	8.03	22.23	1.48	4.57	1.90

* Weiske, l. c.

	Arvepr. Eiland.	Niakornak.* Jakobsh. D.	Fortune Bay, Disco.	Fiakernæs Godthaab, D.	Ekaluit, Nugasuak.	Greenland Knives.
Cu	0.06	0.16	0.20	0.36	0.23	0.18 trace
Fe	95.67	92.46	92.68	92.23	94.11	? ?
Ni	—	1.92	2.54	2.73	2.85	0.23 } 7.76
Co	trace?	0.93	0.58	0.84	1.07	? } 0.56
S	0.09	0.59	0.01	—	?	? ?
C	1.94	3.11	2.40	0.20	?	? ?
SiO ₂ ..	1.40	0.24	0.31	0.64	—	? ?
Al ₂ O ₃ ..	—	—	—	0.64	—	? ?
Insol.	1.09	1.09	0.08	1.99	0.61	? ?

* Contains also 0.07 per cent. of phosphorus. D means district.

It is remarkable that the amount of copper in the second analysis was very small, scarcely to be perceived, but still more astonishing is it that the percentage of cobalt does not increase in the same proportion as the nickel. Somewhat similar is the case in the analysis of L. Smith mentioned above.

III. GRAPHITIC FELSPAR.

When some years ago Dr. Nauckhoff made his careful analyses of the iron and rocks from Blaafjeld, he unfortunately chose a series of specimens which were *so faintly distinguished from each other*, that it is nearly impossible to get a clear view of the subject from them. If we compare the analyses, we find between several of them, for instance between Nos. 7, 8, 9, and 10, some resemblance as well in the mass-analysis as in the mineralogical composition. A low percentage of silica, and a high one of alumina, is characteristic in these four specimens; as also the presence of a red mineral, which Nauckhoff believes is spinel and partially also graphite. Nauckhoff has not taken much notice of the graphite, but L. Smith specially examined "*la dolérite graphitique*," as he calls it.* One point at that time was whether the rock at Blaafjeld did or did not contain anorthite, which was denied both by Steenstrup and L. Smith. Dr. Törnebohm, however, who made his examination nearly at the same time as L. Smith, subjected the specimens formerly analysed by Nauckhoff to a microscopic examination, and singled out from the rest, under the name of "*anorthitfels*," some parts of the rock which appear to belong to the very same variety that L. Smith examined chemically as well as optically without finding any anorthite. It is the merit of Dr. Törnebohm to have first called our attention to this point, but, as the results of these investigations are so different, I thought that the examination ought to be taken up again.

* l. c pp. 481, &c.

Another motive for doing this was that this peculiar rock, which is imbedded as smaller inclusions in the basalt and dolerite proper, is by no means found at Blaafjeld alone, but accompanies the iron in other places, it must necessarily be inferred that there is some connection between them. In this rock are also found some reddish grains—the red mineral mentioned above—which have also given rise to different interpretations; while Nauckhoff correctly regards them as spinel, Smith, after examining them chemically and optically, believes them to be corundum. In the specimens examined by me, the felspar always exhibited excellently reflecting cleavage-faces, even when very much graphite was disseminated in it. The latter may be intermingled in smaller or larger quantities; sometimes it forms so large a proportion of the rock, that the same is more like an impure graphite than a graphitic felspar. I have made a closer examination of specimens of this rock from Blaafjeld as well as from Nuk in the Waigat. The reasons that I have examined the felspar from Nuk and not that taken from the other localities whence the iron also was examined will be explained below.

Steenstrup and L. Smith, who have denied the presence of anorthite at Blaafjeld, have described the felspar as labradorite. Both of them have treated sections of the rock with hydrochloric acid without any effect; L. Smith has further treated the pulverised rock with hydrochloric acid, without being able to detect lime in the solution; which undoubtedly would have been the case if he had had to do with anorthite. The explanation may be that these experiments have been made on the basalt proper, not on the graphitic felspar (anorthitfels), the question then being whether the rock around the iron blocks was eucrite or basalt.

I therefore tried to treat a little more than three grains of the graphitic felspar with cold hydrochloric acid of twenty-four per cent. for forty-eight hours, the solution being occasionally stirred up. Hereby 4.2 per cent. of lime and a little magnesia were dissolved, besides iron oxides and alumina. I therefore agree with Dr. Törnebohm that this triclinic felspar, which is so easily decomposed by hydrochloric acid, is really anorthite. Mr. Steenstrup has ground a section of the same specimen that was used for the analysis. This section was put in hydrochloric acid in a test-tube, one end of which had been drawn out flat in such a manner that the glass might be laid under the microscope, and the progress of the decomposition of the felspar be observed. The section was broken by degrees into smaller pieces, but it might be observed in every piece how veins of an isotropic matter were formed, and how these veins were gradually widened, the unaffected parts getting smaller. That this

D

isotropic matter should only be amorphous silica seemed rather doubtful, as the section must, if this be the case, have been broken at each of the veins.

I am now coming to the red grains, the spinels of Nauckhoff and Törnebohm, the corundum of L. Smith; although the latter investigator, on account of "chemical criterions," also deems the presence of spinel to be possible. Really the chemical as well as the optical criterions speak in favour of spinel being present, and it seems strange that it has escaped the attention of the renowned American chemist, that under the microscope the reddish grains appear dark in all positions between crossed Nicols. This seemed to make it certain that the mineral was crystallising in the tesseral system, not hexagonally. I ought yet to add, that Prof. L. Smith himself remarks that the mineral probably is corundum, "*quoique les observations optiques ne soient pas certains.*"

For isolating the spinel he used two different methods. On the first occasion the graphite was burnt in a current of oxygen, and the heated residue was fused with alkaline carbonates to which a little caustic soda was added. The fused mass was treated with water and hydrochloric acid; on the undissolved residue the fusing and treating with acid was repeated. A small portion still remained, which was only decomposed by bisulphate of potash. It had the following composition:

SiO ₂	...	...	...	...	0.95
Al ₂ O ₃	...	...	...	...	92.02
Fe ₂ O ₃	...	...	...	...	8.25
MgO	...	...	...	...	2.68

98.90

The second time, the rock was first treated with hydrofluoric acid, then the graphite was burnt in oxygen—a very long process—then the residue was fused with carbonate of soda, and in the residue after all these operations 98 per cent. of alumina were found. Already the difference in the percentage of alumina is striking. I think that the amount of magnesia found in the first analysis are the chemical indications, from which L. Smith has drawn his conclusion as to the presence of spinel.

It at once appeared rather doubtful to me whether the spinel, if we really had to do with spinel, might pass uninjured through these violent processes, and therefore I tried to isolate it in another manner, in doing which I succeeded very well.

If the rock in a coarsely pulverised state is put gradually in small quantities into a mixture of saltpetre and carbonate of soda, the latter being kept fused at a very high temperature, the graphite will be oxidised and

the silicates will be decomposed in a very short time. After cooling the mass is thoroughly well elutriated. After elutriation with hot water, the residue was treated several times with concentrated hydrochloric acid, and after that the spinel was found quite isolated. 12 grs. of the rock afforded when treated in this way 1 gr. spinel in the form of hard dark grains, which when seen by transmitted light appear red. When laid in Canada balsam and viewed under the microscope, they also here appear red and quite fresh, and there is on the whole no difference whatever to be found between these and other grains still imbedded in the rock. The hardness surpasses that of quartz and the specific gravity is 8.45.

For the analysis the mineral was pulverised in a steel mortar. The metallic iron, which by this process had been mixed up with the mineral, was dissolved by hydrochloric acid. 0.2995 gr. then afforded the following composition :—

SiO ₂	...	...	...	...	0.20
Al ₂ O ₃ (Fe ₂ O ₃)	...	...	...	...	80.60
Cr ₂ O ₃	...	..	...	...	1.24
MgO	...	...	..	...	19.11

101.15

Unfortunately I lost part of the solution in which the iron was to be determined volumetrically, but that some amount was present might safely be assumed. In the analysis the iron is given in the form of sesquioxide together with alumina, but part of it must be protoxide, which would explain the excess. In a previous analysis, made on 0.4805 gr., I found 19.57 per cent. magnesia. If then 19 per cent. MgO be added to some amount of iron oxides, we have between 20 and 30 per cent. of strong bases combined with 70 per cent. alumina, and 1 per cent. chromium oxide, wherefore I do not hesitate to pronounce the mineral to be a real *chrome-coloured spinel*.

I have further analysed *the rock itself*, the graphite being burnt in a current of oxygen and determined as carbonic acid. Results :

Graphite	...	...	...	6.78
Residue	...	...	...	93.22

100.00

The residue was really smaller, and the loss by heat considerably larger, viz. 10.28 per cent., thus something must have been lost besides the carbon. The residue was decomposed by carbonate of soda, and showed the following composition :

SiO ₂ ...	...	...	...	89.75
Al ₂ O ₃ ...	...	...	...	26.08
Cr ₂ O ₃	...	...	...	1.28
Fe ₂ O ₃	...	...	...	12.88
CaO ...	...	...	...	12.01
MgO ...	...	...	...	4.51

I did not succeed here in isolating the spinel, which must have been more easily decomposable, in consequence of its having been kept for 20 hours heated in oxygen, a proceeding which was necessary to have the graphite burnt. The amount of magnesia and chromium-oxide may be derived partially from the spinel. Considering that neither the graphite nor any of the other constituents of this rock perhaps ever occur in the same relative proportion (L. Smith for instance found 17.50 per cent. graphite), it is not to be expected that analyses of different, nay even of the same specimens, will give the same results. It may then be of some interest to compare the analyses which have been made wholly or partially on this rock, and therefore I communicate below an abstract of the analyses of Nauckhoff, nos. 7 (I.), 10 (II.), 9 (III.), 8 (IV.) placed together with that of L. Smith and my own. Only it ought to be remembered that the graphite in the two latter analyses had been removed beforehand.

	Nauckhoff.				Smith.	Lorenzen.
	I.	II.	III.	IV.		
SiO ₂	84.72	87.92	44.94	86.59	84.16	89.75
Al ₂ O ₃	81.88	82.86	22.20	19.18	88.85	26.08
Cr ₂ O ₃	—	0.08	—	—	—	1.28
Fe ₂ O ₃	4.88	—	—	—	—	12.88
FeO	5.58	4.02	9.45	14.85	17.00	—
CaO	10.19	11.57	11.01	8.78	8.80	12.01
MgO	9.85	2.86	4.98	7.24	4.28	4.51
C	0.58	6.90	8.85	2.55		

Between the results, inconsistent as they are in other respects, there are yet some accordances, as in the low amount of silica and the high percentage of alumina and partially also of lime.

With a view to ascertaining whether the results here found agreed with what might be observed at the other iron localities, I also examined the felspar from Nuk in the Waigat. Mr. Steenstrup had observed that in some places the red spinels occurred along with a wine-yellow mineral, most abundant at Nuk, although it seemed doubtful whether even from this locality sufficient material for an analysis might be obtained. This was an inducement to examine this felspar, although I had not analysed

the iron from this place. For isolating the minerals, I used the method described above. 30 gr. were employed, but the two minerals occurring only in very small quantities the difficulties of the operation were very much augmented, and I obtained so small an amount, that it did not suffice for an analysis. When put in Canada balsam and tried in polarised light, the yellow grains proved to be anisotropic, and therefore could not be spinel. They appeared fully fresh, but whether they be quartz or another mineral I am not able to decide.

In order to ascertain whether the felspar in this rock, which did not contain as much graphite as the Blaafjeld specimens, was also anorthite, I treated 3.044 grs. with cold hydrochloric acid of 24 per cent. during 48 hours. A large amount of iron oxides, a little magnesia, and 0.048 gr. or 1.41 per cent. lime were dissolved. Though not so much lime by far is dissolved here as in the Blaafjeld specimens, yet I think it is sufficient to warrant the belief that this felspar is also anorthite, considering the likeness existing throughout between the felspar in question and that of Blaafjeld.

It has been necessary to enter into these details respecting the composition of this graphitic felspar, on account of the close connection existing between this peculiar and interesting rock and the iron. It seems certain that it is not possible to account for the origin of the iron without also explaining whence the rock therewith connected has come. I do not think that, after the recent discoveries of Mr. Steenstrup, the meteoric origin of the iron will be seriously asserted. Thus two alternatives are left, viz. that the iron may have either been carried up with the basalt, when in a fluid state it broke forth from the interior of the earth, or, that it may have been originated, during or after the eruption, through a reduction of the ferruginous minerals contained in the basalt, especially the magnetite and olivine. If we accept the theory put forth by Dr. Törnebohm, which seems a very plausible one, that the graphitic felspar has originated from a marl or slate rich in lime, alumina, and carbon, and if we remember that the Greenland basalt has in many places broken forth through coal-beds, the conjecture is probable that pieces of such beds of coal and slate were broken off, and as far as the inorganic constituents were concerned, were remelted, whereby oxides of iron were reduced to metal. On account of some very interesting microscopical examinations, Dr. Törnebohm holds it rather probable that the iron may have been reduced after the congealing of the basalt by means of bituminous matter accumulated in vesicles or cavities. To me it seems more natural to assume that the iron has been produced by the dry way, in a manner similar to that

by which we make iron technically. Perhaps we may expect important contributions towards a solution of the problem from a closer microscopical examination of the way in which the iron occurs in the other localities.

As I had thought it possible that the basalt of Blaafield, where such large blocks of iron had been formed, might contain somewhat less of combined iron, I made a series of experiments with the view to ascertain whether this might be the case. I took fragments of basalt adhering to the blocks themselves, examined them by the lens to see if they were partly of pyrrhotite and iron; decomposed them with hydrofluoric acid, reduced with zinc and determined the iron volumetrically. Although these experiments do not supply any evidence bearing upon the above view, yet I think it right to give an account of them. It appears that all the specimens tested contained the same quantity of iron as is usually found in basalt. Although there is a little difference in a few of them, it is too slight to decide anything. The whole quantity is given as protoxide. The results were:

I.	...	...	...	12.95 per cent. FeO.
II.	...	...	...	12.84 „
III.	...	...	...	18.68 „
IV.	...	...	...	14.65 „
V.	...	...	...	14.86 „
VI.	...	...	...	11.28 „
VII.	...	...	...	14.90 „

I. is compact basalt. The specimen had been surrounded with iron on all sides.

II., III., IV. and V. are all taken from basalt adhering to different pieces of iron.

VI. was taken from a large piece of fine-grained dolerite, which had been in immediate contact with the iron.

VII. finally was taken *in situ* on the shore 50 feet west of the iron.

It may be added that, although it would have been a strong evidence in favour of the reduction theory if it had been proved that the amount of iron oxide had diminished in the basalt around the metallic iron, yet, of course, the above experiments by no means prove that the theory is wrong, but only that we do not get further on this way.

If we assume with Daubrée that the metallic iron has been carried up from the interior of the earth, we meet with a difficulty in explaining whence the graphitic felspar originates, as it does not seem easy to understand that the like origin could be attributed to the latter; and the latest investigations of Mr. Steenstrup distinctly show that the iron and the felspar are so closely connected that their origin must be supposed to be attributed to the same causes.

III. *On some Specimens of Lava from Old Providence Island.*

By PROF. T. G. BONNEY, D.Sc., F.R.S., F.G.S., PRESIDENT.

[Read December 11th, 1883.]

SOME months since I received from J. G. Grenfell, Esq., of Clifton College, a few small specimens of igneous rock which he had collected in the year 1880 on Old Providence Island. This is an island in the Caribbean Sea about 90 miles off the Mosquito Coast, in lat. $18^{\circ}26' N$, long. $81^{\circ}18' W$. It is oval in shape, $4\frac{1}{2}$ miles long from N to S, and $2\frac{1}{2}$ miles wide. Barely separated from it on the North is a little island named Sta. Catalina. Mr. Grenfell describes the main island as mountainous, with three chief peaks, the highest of which rises to 1,190 ft. Spurs from these terminate on the shore in peaked hills from 800 to 700 feet high. The materials of both islands, as far as seen, were volcanic—lavas, tuffs and agglomerates; but the fragmental materials on Split Hill exhibited a more uniform stratification than we should have expected in débris simply ejected from a volcano. The rocks numbered (d) and (e) come from a cave near Morgan's Head on the west coast of Sta. Catalina, the others represent the ordinary igneous rock of Old Providence. The specimens consist of bits of dull reddish scoria, of a rather decomposed pale purplish-red or reddish-lavender porphyritic rock and a nearly black minutely porphyritic rock. All appeared to belong to a group of rather basic lavas; and on the first glance at the last named I was at once struck with its resemblance to those compact black lavas variously named augite-andesites, pitchstone porphyrites, &c., which have recently attracted so much attention as containing a rhombic pyroxene, possibly hypersthene. I selected five of the more promising varieties for microscopic examination, and append the following description:—

(a). A brown-black rock, almost as dark as many basalts, fracture rather irregular with a slight rather resinous lustre, structure compact, numerous brownish-grey crystals of felspar from about $\frac{1}{16}$ " to $\frac{1}{8}$ " long, rather square in outline, also very small crystals of a black pyroxenic mineral, outer surface not decomposed and slightly pitted. Under the microscope the rock exhibits a brown glassy base of minutely granulated aspect; this is due to its being rather thickly studded with very minute crystallites and granules of felspar, pyroxene and opacite. In this are scattered, fairly

thickly, larger grains of opacite and crystals of felspar and a pyroxenic mineral. The felspar is rather variable in form, but the crystals are generally approximately oblong in outline, the breadth being not seldom about half the length. Most if not all are obviously plagioclase; some show zonal banding, many polysynthetic twinning, though a 'Carlsbad' habit is not unfrequent. The extinction angle between successive lamellæ commonly varies from 20° to 80° , and sometimes exceeds the latter amount, and the least angle made with a vibration plane of one of the Nicols by the edge of a crystal is about 10° . I have little doubt that these crystals are either anorthite or labradorite, possibly both. Some of the crystals are almost clear, but the majority contain inclusions. Many of these are brown glass, which is sometimes quite clean, but at others contains opacite and other crystallites; for these enclosures I cannot make out any rule, they are not restricted to the larger crystals. Granules of a pyroxenic mineral are often included. Here and there a crystal appears to become fused into the adjacent base by being crowded with crystallites. In short these felspars exhibit the usual features of crystals which occur in rocks of this nature. There may also be some cavities, but I do not detect any bubbles. The pyroxenic constituent is fairly abundant. It has a rather fibrous look, is slightly dichroic; the prisms extinguish as nearly as possible parallel to their edges. In cross section the pinacoidal planes are best developed, the prismatic cleavages are the more prominent and constant, and the plane of the optic axes appears to be parallel with a pinacoidal face. The green tint is most marked in a longitudinal section when its axis is parallel with the vibration plane of the polariser (alone), the red when transverse. In two parts of the slide the felspar crystals are grouped so as to enclose a portion of the base. This, however, differs from that outside in being a clear brown glass with only a few granules of opacite, and in one case two or three small crystals of the rhombic pyroxene.

(b). A rock generally similar to the above, but slightly browner, and a shade rougher in fracture, and less lustrous. Under the microscope the ground-mass has not quite such a glassy aspect, as the included crystallites (doubtless of felspar) are rather larger and give to the slide more of a 'felted' look. The larger crystals of felspar are similar to the above, but with fewer glass enclosures. There is some of the rhombic pyroxene, but certain other crystals appear to be normal augite, well marked octagonal prisms being fairly abundant; there are larger grains of iron peroxide.

(c). Differs but little from the above, macroscopically or microscopically, but is in all respects, especially as regards the matrix, a little nearer to (a). The description of that will apply to the larger crystals of this, word for word.

(d). A compact purplish-grey moderately dark rock, clouded here and there with a dull red, with small dead-white crystals of felspar scattered about. It weathers to a pale lavender-grey, and was selected as the most hopeful example of the more decomposed specimens. Under the microscope we see that, allowing for its condition, it has a general resemblance to the above described, being perhaps nearest to (b); the larger crystals are less numerous, but a decomposed plagioclastic felspar and a grain or two of a black bordered brown pyroxenic mineral can be recognised. Several dark brown globulitic spots and grains of iron oxide are scattered about.

(e). A purplish-red rock, with sundry small vesicles on the outer surface having a decidedly scoriaceous aspect. Minute crystals of a decomposed felspar and a darker mineral are visible. Under the microscope it presents a general resemblance to the above described, but is rather decomposed, and the base is more variable in colour, having a dingy muddled look. The felspar is much decomposed, and has often broken away in the grinding of the slide; the pyroxenic constituent is generally bordered with opacite and darkened, and is thus difficult to determine.

I am indebted to my friend J. J. H. Teall, Esq., M.A., F.G.S. for the following notes on the chemical composition of one of these dark lavas, that from which the slide was prepared from Old Providence Island.

I. "1.0580 gramme of the substance dried at 110°C and fused with the mixed carbonates of soda and potash gave .6486 gr. of silica, .1868 gr. of alumina, .0628 gr. of ferric oxide, .0574 gr. of lime, and .0706 gr. of magnesium pyro-phosphate.

II. "1.0846 gramme heated in a sealed tube with hydrofluoric and sulphuric acids required 4.75c.c. of permanganate of potash solution (1 c.c. = .00551 gr. of Fe.) to convert the ferrous into ferric oxide.

III. "1.1006 gramme, dried at 110 and treated according to Lawrence Smith's method, gave .0994 gr. of the chlorides of sodium and potassium, and .1192 gr. of the double chloride of platinum and potassium.

IV. "1.0578 gr. dried at 110° and heated to redness in a current of air yielded .0269 gr. of water.

Whence it follows that the rock contains :—

SiO ₂	...	...	...	...	61.12 per cent.
Al ₂ O ₃	...	...	...	...	17.78 „
Fe ₂ O ₃	...	...	...	...	2.52 „
FeO	...	...	...	...	8.10 „
CaO	...	...	...	...	5.45 „
MgO	...	...	...	...	2.89 „
Na ₂ O	...	...	...	...	8.01 „
K ₂ O	...	...	...	...	2.09 „
H ₂ O	...	...	...	...	2.54 „

99.95

Specific gravity of specimen analysed 2.582.

“The loss on ignition was 2.81 per cent., a result which is seen to agree very well with the direct determination of water when we remember that the ferrous iron would take up oxygen during ignition.

“The evaporations were all performed in platinum vessels, so that no excess in the analysis, due to the corrosion of glass vessels, is to be expected.”

I am also indebted to the same gentleman for the annexed series of analyses for comparison with the above; from which it will be seen not only that they form a well marked group of closely allied rocks, but also that the difference of the last of these (No. VI.) from the rest and from this Old Providence rock is extremely small. Yet that is a porphyrite from the Cheviots of Old Red Sandstone age, while all the others are later Tertiary or recent. When to this we add the microscopic resemblance noted below, it becomes difficult to maintain the distinction so often, and in my opinion so wrongly asserted to exist between Pre-Tertiary and subsequent igneous rocks.

	I.	II.	III.	IV.
SiO ₂ ...	61.87	60.71	61.64	62.76
Al ₂ O ₃ ...	15.76	16.00	17.44	18.10
Fe ₂ O ₃ ...	4.06	2.09	0.82	5.14
FeO ...	2.94	8.87	8.99	—
MgO ...	2.86	8.07	8.05	2.59
CaO ...	7.27	5.17	5.86	6.03
Na ₂ O ...	8.04	2.74	8.45	8.45
K ₂ O ...	0.71	8.78	1.15	1.85
H ₂ O ...	2.64	1.48	2.64	—
	100.65	99.92	100.04	99.42

			V.	VI.
SiO ₂	...	...	62.00	63.0
Al ₂ O ₃	...	...	17.84	14.9
Fe ₂ O ₃	...	...	—	4.7
FeO	...	...	4.40	—
MgO	...	...	2.64	2.8
CaO	...	...	5.87	4.8
Na ₂ O	...	...	4.29	4.0
K ₂ O	...	...	1.47	1.9
H ₂ O	...	...	1.66	4.0 (Loss).
			99.67*	100.1

I. Hypersthene Andesite—St. Egid, Steierwartz. Niedzwiedski, Min. Mitth. 1872, p. 255. This rock macroscopically bears the closest resemblance to the Old Providence Lava and the Cheviot Andesite.

II. "Augite Andesite"—White Rock, Cedar Mountains, Utah. King, Geol. Expl. of the 40th Parallel, 1877. II. 466.

III. "Augite-Andesite"—Cortez Range, Wagon Canon, Nevada. King, Expl. 40th Parallel, 1877, II. 582.

IV. Andesite from the Volcano of Rincon de la Vieja (Andes). Dr. O. Proeß. Beiträge zur Kenntniss der Trachyte. Neues Jahrbuch 1866, p. 652.

V. Pumice of a Hypersthene-andesite from Mount Shasta. A. Hague and J. P. Iddings, American Journal of Science, 1889, p. 280.

VI. Andesite with Rhombic Pyroxene, Cheviot. Teall, Geol. Mag. March 1888.

Nos. I., II., and III. are quoted from Roth's Beiträge zur Petrographie der plutonische Gesteine.

From the above description it is evident that we have in these specimens from Old Providence Island representatives of the group of Augite Andesites, which contain a rhombic pyroxene, probably hypersthene. This group, as is well known, has recently attracted much attention, and I may refer readers for further particulars and for references on the subject to the excellent Papers of Mr. Teall and Mr. Waller in the *Geological Magazine* (Dec. II. Vol. x. pp. 100, 252, 290). To the former gentleman I am indebted for the opportunity of comparing these Old Providence specimens with several slides obtained from various localities. The resemblance is in some cases very striking; the Old Providence specimens (especially *a*, *b*, *c*) closely resemble in their microscopic structure an

* With TiO₂ = 0.17, P₂O₅ 0.29 total in all 100.13. There was a trace of MnO.

'augite andesite' from Bagonya, and another from Dolny Tured, Kremnitz, also anorthite trachytes from Lorinczi, from Aphroessa (Santorin), (1866), and "Kleiner Eliasberg" Thera. They present also considerable resemblance to his slides of "Pitchstone porphyrite" from the Cheviots, especially from Carl Croft, Blindburn, Fernhaugh, Windyhaugh, Cognet, and Alvin; and to one of the same rock (though less close) from a foreign locality, Vethalm. I also note a resemblance to an anorthite-trachyte from Matra, and from Borac (S. Servia) in my own collection. There are also resemblances macroscopic and microscopic to some specimens brought me by Mr. Whympers from Antisana, Pichincha, and Chimborazo (Andes) and macroscopic to specimens in my collection from Kremnitz.

A paper has recently been published by Messrs. A. Hagne and J. P. Iddings (Notes on the Volcanoes of Northern California, Oregon, and Washington Territory*), to which Mr. Teall and Prof. Judd have both called my attention, giving a very full description of the andesites of Lassens Peak, Mount Hood, Mount Shasta, and Mount Ranier, extinct volcanoes, now forming lofty peaks in the chain of the Sierra Nevada. These observers were successful in isolating a sufficient quantity of the rhombic pyroxene for chemical analysis, with the following result:—

SiO ₂	...	...	...	...	50.83
Al ₂ O ₃	...	...	...	...	0.97
FeO	...	...	...	...	22.0
CaO	...	...	...	...	1.88
MgO	...	...	...	...	28.29
MnO	...	...	...	...	0.64

99.11

Optical examination of isolated crystals also confirmed its orthorhombic character: so there can be little doubt that the mineral is a true hypersthene. The authors also call attention to the fact that "hypersthene is the substitute for olivine in rocks, differing from basalt in a somewhat higher silica percentage, the former mineral being as it is simply the bisilicate of the same Fe Mg elements." It is however noteworthy that the most frequent associate of olivine in the peridotites is not hypersthene but some variety of the closely allied mineral enstatite, usually bronzite. (Compare with this the occurrence of diallage in gabbro, the peridotites appearing to be generally deep-seated rocks.)

* *Amer. Jour. Scien.* Vol. xxvi. p. 222.

The investigations of these gentlemen fully confirm those of Mr. W. Cross and Prof. Fouqué, so that we need not hesitate to admit this rhombic pyroxene to be a true hypersthene, and recognise a rather extensive and wide-spread group of rocks characterised by its presence, to which belong these lavas of Old Providence island. It will perhaps hardly be necessary to form a distinct species for them, or mark them off more strongly from the normal augite-andesites than, in the case of basalts, we should separate one from which olivine is absent, from one in which it is rather abundant. Examination of the peridotites shows us that the presence of enstatite (bronzite), augite, or hornblende, has hardly more than a varietal value, but we may conveniently form a sub-group, hypersthene-augite-andesites which will be related to the normal augite-andesites, much as olivine-basalts are to normal basalts.

IV. *Note on a New Mode of Occurrence of Garnet.*

By H. LOUIS, Assoc.R.S.M.

[Read December 11th, 1883.]

GARNET is most commonly found in the form of separate crystals embedded in metamorphic rocks; occasionally, but comparatively rarely, in beds or veins. On a recent visit to the Pyrenees, in the Province of Catalonia, I found this mineral forming what appears to be a true dyke. I first noticed an outcrop of it in the steep banks of a brook, in one of the higher valleys of the main mountain chain. At this point it had the appearance of a vein, almost vertical and running nearly East and West; the wall rock was a highly metamorphic schist, so that its stratigraphical relation to the garnet could not well be made out; however, the general strike of the strata in this district is about East and West. At this point the dyke was about 2' thick; one of its walls was exposed, and appeared to have undergone a good deal of alteration, being darker in colour, more fissile and more friable than the shales at a little distance off; it had also been mineralised by the development in it of small disseminated crystals of iron pyrites. On crossing the brook, I found the same phenomena repeated at a point facing the above mentioned, and on top of the hill fronting and at a distance of some 800 yards from the first locality a third outcrop, all in the same direction, was visible; these three exposures were evidently all on the same dyke. On top of the hill the dyke was about 18" thick, and the wall-rock consisted of chloritic schists, containing embedded garnets and iron pyrites. At a distance of over a mile from this spot, but in a direction which I could unfortunately not determine, as heavy mists were obscuring the view, I found another outcrop of the same mineral. Here the dyke was very thick, measuring some $5\frac{1}{2}$ yards across, of pure massive garnet rock, free from intermixture with any other mineral, except a little calcite occasionally near the walls. One wall of the dyke consisted of a mass of highly crystalline white limestone, traversed in places by thin films of amianthus. On the other wall an old level had been driven, which was completely blocked up at the time of my visit; the object of the level seems to have been to get what is probably the mineralised wall of the dyke, the minerals obtained being iron pyrites and zinc blende principally.

The garnet from these various localities seems to be exactly similar. It is massive crystalline and very free from impurity; whenever any cavity occurred in the mass it was always covered with well-formed crystals, exhibiting usually the faces of the rhombic dodecahedron and the icositetrahedron ($\infty 0$ and 202).

The mineral is rather brittle, its hardness seems low for garnet, and its specific gravity high, being 3.58; hence it is in all probability an iron garnet. Subjoined is a rough analysis:—

SiO ₂	...	88.56	88.42
Al ₂ O ₃	...	15.64	
Fe ₂ O ₃	...	9.75	
MnO	...	10.89	10.86
CaO	...	26.92	26.90
		96.26	

Magnesia, alkalis, water, &c., not determined.

Formula about 2 (SiO₂, R₂, O₃) + 3 (SiO₂, 2 RO).

V. *Note on a Case of Replacement of Quartz by Fluor Spar.*

By the REV. PROF. T. G. BONNEY, D.Sc., F.R.S., PRESIDENT.

[Read February 12th, 1884.]

THIS unusual substitution appears to have taken place in a rock found by Mr. R. N. Worth, F.G.S., on Trowlesworthy Tor. The specimen was a loose block, and the rock to which Mr. Worth has given the name of Trowlesworthite has not yet been discovered *in situ*. The rock consists of red felspar, fluor-spar, and tourmaline, associated with quartz, and its general character and microscopic structure are described in papers published in the Transactions of the Royal Geological Society of Cornwall, Vol. X. p. 177. The reasons for believing that the rock had been formed from the normal granite of the neighbourhood by substitution of fluor spar from the quartz were the following:—

(1). The fluor-spar occupies about the same proportion of, and is similarly dispersed in the Trowlesworthite as the quartz in the normal granite.

(2). The quartz in the Trowlesworthite is in such intimate association with the black tourmaline, that it seems most probable that this, as in Luxullyanite (see *Min. Mag.* Vol. I. p. 215) is formed from the destruction of a certain part of the felspar, when a considerable amount of silica would be set free; brown tourmaline replacing the mica as in that rock.

(3). The quartz in the normal granite is very full of microlithic enclosures and cavities, while that in the Trowlesworthite is unusually free from these. Using a popular term, the one when viewed with a low-power objective looks 'dirty,' the other 'clean.' To this rule one grain only in the latter rock is an exception, and in that the needles of black tourmaline are wholly wanting.

VI. Notes on "*Enargite*," from Montana, U.S.A.

By WM. SEMMONS, Past President of the Liverpool Geological Society.

[Read February 12th, 1884.]

THE deleterious effects of small quantities of Arsenic when present in Copper are well known to all who are concerned with the working of this latter metal, and the elimination thereof is consequently an object to which the copper smelter pays special care. Though a large number of minerals, some of which are of exceeding beauty, are found composed of Copper combined with Arsenic acid, the direct combinations, as Arsenide and Sulph-Arsenide, are comparatively rare.

Dealing to-night only with the latter group, we notice that Brooke and Miller in the 1852 edition mention as its sole representative "*Tennantite*," with its variety *Kupferblende*, and note its occurrence in small attached crystals rarely massive. In the appendix another representative is added, "*Enargite*" from Peru. Dana, in 1874, "*System of Mineralogy*," gives no new combinations, but adds the further localities for *Enargite*—New Grenada, Mexico, South Carolina and Colorado. By this time too Breithaupt, Rammelsberg and Dauber had been able to measure its crystals and describe more fully its physical characters. In the first supplement of the "*System*" a mineral occurring in small black brilliant crystals, also massive and containing copper, sulphur, arsenic, and 6 per cent. antimony, and found in California, is given as a variety of *Enargite*.

Famatinite containing 10.98 per cent. antimony and 6.48 iron, but otherwise agreeing with *Enargite* and being found with it, is mentioned in Appendix III. The angles of Famatinite were found by Vom Rath to be identical with those of *Enargite*.

Clarite from Baden having the composition of *Enargite*, but differing from it in colour, was named by Sandberger in 1874.

Luzonite from Luzon Island, Manilla, was described by Weisbach in 1874. It is of nearly similar composition to *Enargite*, but differs from it in cleavage and colour. Dana and Brush consider Clarite and Luzonite are only varieties of *Enargite*.

These being so far as I knew the only localities where minerals of this composition had been obtained, it was with exceeding interest that I heard of an ore being found in Montana containing 20 per cent. of arsenic. Through the kindness of my friends Messrs. Lawn and Davey I was enabled

E

to obtain several specimens, and have now the honour of submitting the result of my investigations to this Society.

Crystals are very rare, and are small when found. Though not clearly defined enough to enable measurements to be taken, the crystals give the planes of the rhombic prism, also those of the macro-pinacoid and brachy-pinacoid terminated by macro- and brachy-domes and the basal-pinacoid. The symmetry is therefore that of the ortho-rhombic system. The cleavage planes are remarkably distinct and coincident with those of the rhombic prism and of the basal-pinacoid. They are highly striated like those of stibinite. The mineral thus cleaves into little rhombic prisms. Fracture uneven.

The hardness may be taken as 2·5, for it leaves a black powder on calcite, while it easily scratches gypsum. It soils the fingers when handled. The specific gravity, taking the mean of several specimens, is 4·8. Mr. Grenville Cole, F.G.S., of the Normal School of Science, South Kensington, determined the S.G. of a large specimen with a little quartz in it as 3·92 (by Walker's method), which may be regarded as confirmatory of my results. Colour when fresh broken is lead-grey, but it rapidly tarnishes on exposure, and becomes darker, when it much resembles blende. Streak black.

Pyrognostic Characters.—In closed and open tubes gives ordinary reactions for sulphur and arsenic. The mineral decrepitates at first and also exfoliates before the blowpipe, giving rise to worm-like threads, vermiform. I was much interested when testing the mineral before the blowpipe to find it gave no indications of antimony being present. Its appearance and structure are so similar to Stibnite, that one almost unconsciously looked for the antimony sublimate. But notwithstanding I worked with the aluminium plate of Ross, I could not find a trace of antimony. I therefore asked Mr. Lionel Fulcher of the City of London College, and Mr. Aug. Loos of the Peckham Technical School to test for antimony specially, and the result of their kind efforts agreed with mine. Thereupon my friend Mr. Terrill of Swansea very kindly undertook to make a complete analysis, and the results of two he made are given below—

				I.	II.
Copper	...	...	...	45·80	45·76
Arsenic	...	...	...	18·64	18·66
Sulphur	...	...	...	81·30	81·80
Silica	...	...	...	2·50	2·50
Iron	...	...	...	·80	·80
				99·04	99·02

The silica is evidently an impurity, and the proportions of copper, arsenic and sulphur stand as

Copper 47·84 per cent.

Arsenic 19·47 „

Sulphur 32·69 „

100·00

The composition is therefore nearly the same as Enargite; but as it differs from this mineral in hardness, cleavage, and pyrognostic characters, I should be inclined to give it a distinctive name, and class it under the Enargite group of sulph-arsenides of copper with Famatinite, Clarite, Luzonite and Guayacanite. All these are essentially similar in composition with a formula $8 \text{ Cu}_2 \text{ S} + (\text{As Sb})_2 \text{ S}_2$, but differ in structure and other physical characters from one another sufficiently to be called under specific names.

The mineral is found with pyrites, bornite, covellite and quartz in Montana, U.S.A.

VII. *Analysis of an altered Siderite from Helton Beacon Lead Mine, near Appleby.*

By C. O. TRECHMANN, Ph.D., F.G.S.

[Read February 12th, 1884.]

IT appeared of interest to determine the nature of the alteration which has changed the light greenish or brownish yellow siderite to the dark, almost perfectly black, glossy crystals so often seen on specimens from this neighbourhood.

The material, gathered from the heap of a mine, consisted of massive siderite, crystallised on its natural surfaces in the form of small curved primary rhombohedrons, and associated with quartz, pyrites, blende, and other minerals. The alteration had commenced on the more exposed external parts, and had gradually extended inwards to a depth of about one eighth of an inch, though here and there in deeper cavities the crystals remained quite fresh. The colours ranged from black, or deep blackish brown, through purplish brown and light brown to the yellowish or greenish original tint. There is no perceptible difference in the vitreous lustre of the fresh and altered parts.

For analysis only the most altered crystals were detached and carefully selected, in order to secure as nearly as possible the most advanced stage of the alteration. The rust-brown powder was dried at about 100° C. (a loss of weight of about 1 per cent. occurred, which appeared due in part to hygroscopic moisture) and was submitted to analysis with the following result :

	I.	II.	III.
CO ² ...	88.49	—	—
SiO ² (gangue)	1.58	1.65	—
FeO* ...	—	51.50	—
MnO ...	—	5.92	—
CaO ...	—	8.21	—
MgO ...	—	2.86	—
H ² O ...	—	—	1.48

* The iron is all given as FeO for simplicity.

From these numbers I have calculated the composition as under :

				<i>Atomic ratio.</i>	
SiO ² (gangue)	...	1.59	—	—	
FeCO ³	...	68.69	—	—	
MnCO ³	...	9.59	—	—	
CaCO ³	...	5.72	—	—	
MgCO ³	...	6.01	—	—	
Fe ² O ³	...	18.80	881	1	
H ² O	...	1.48	822	1	
			101.88		

No attempt was made to determine the state of oxidation of the manganese in presence of a ferrous salt, and in the calculation I have therefore assumed that the manganese carbonate was unaltered, and that only the ferrous carbonate had suffered a change. It is, however, probable that it has also been in part decomposed to manganic hydrate; in which case the result of the calculation will not be impaired because the atomic weights of iron and manganese are so nearly alike.

The atomic ratio of the ferric oxide and the water given off at red heat seems to suggest that the hydrate has a constitution similar to that of Göthite (Fe²O³, H²O), and that on further alteration more water may be taken up.

VIII. *Notes on a Picrite (Palæopicrite) and other Rocks from Gipps' Land, and a Serpentine from Tasmania.*

By PROFESSOR T. G. BONNEY, D.Sc., F.R.S., F.G.S., &c., PRESIDENT.

[Read February 12th, 1884.]

THE rocks whose microscopic structure is described in this paper were collected by my friend, M. G. Stuart, Esq., during a tour in Australia, under the kind auspices of A. W. Howitt, Esq., F.G.S., the well-known geologist, who has so largely added to our knowledge of one of the most interesting districts of that continent.* Some of them have been already noticed by that gentleman, but as the volumes in which his descriptions are published are not very accessible to English readers, and as two of them are rocks to which I have devoted special attention, I have ventured to bring them to the notice of our Society.

Swift's Creek, Gipps' Land.—Picrite.—A moderately coarsely crystalline dark green rock, containing crystals, up to about $\frac{1}{2}$ inch diameter, of a blackish mineral, with two easy cleavages meeting at angles of about 120° . Their surfaces have a bright lustre, and are interrupted by enclosures of a non-reflecting mineral. In this respect they much resemble bastite, but the peculiar 'brassy' appearance of that mineral is wanting. The rock weathers brown, and is extremely like the picrite of Schriesheim in the Odenwald. The predominant mineral in the slide is a pale green hornblende, which is clearly the mineral of the larger crystals, and occasionally occurs in aggregated smaller crystals. It is not very strongly dichroic, but gives characteristic extinction angles and cleavages. Associated irregularly with this, and seemingly having solidified rather prior to it, is a slightly brownish, almost colourless, and sometimes rather 'dirty looking' mineral, which from its cleavage and extinction angles (not very easy to observe owing to the granular habit of the mineral) appears to be an augite, with a rather diallagic habit. From its relation to the hornblende I cannot help suspecting that much of the latter is of secondary origin—a kind of uralite—as I have already observed in other picrites. Irregularly interspersed

* *Quar. Jour. Geo. Soc.* Vol. XXXV. p. 1. See also the volumes of the *Victoria Geol. Survey*.

about the slide and forming the interruptions to the larger hornblende crystals are grains of olivine, fairly well preserved, except that the cracks are outlined by a black staining. Here and there incipient serpentinisation may be noted, and from the brown colour of the result, as well as from the above staining, I should infer that the olivine was rather rich in iron. Scattered very irregularly about the slide, but often roughly grouped, are several small grains of a rather resinous looking, clear, but darkish sap-green colour. They exhibit indications of a cleavage probably octahedral, and do not depolarise light, so that I think I may venture to identify them with picotite (pleonaste). It much resembles that described in my paper on the Lherzolite of the Ariège (*Geol. Mag.* Dec. II. Vol. IV. p. 59), but is yet more distinctly green, having no tinge at all of brown.* In one or two cases the grains have almost a filmy aspect, and are enclosures in a hornblende crystal. A few grains of a black iron peroxide are scattered about, and in one part of the slide there is a little of a plagioclastic felspar. I note a flake or two of brown mica in the rock, but it happens not to occur in the slide. The rock is therefore a very typical picrite (or 'palæopicrite' of many authors), and in chemical composition probably differs little from the Schriesheim rock, except that we may expect a small amount of chromium to be present.

Diorite (typical), Gipps Land.—A moderately coarse crystalline white and dull green rock, of slightly foliated aspect. Under the microscope it is seen to consist of felspar (plagioclastic), quartz, and about equal quantities of green hornblende and brown mica. The felspar is in fair sized, generally well-defined crystals, with characteristic twinning. It is not very well preserved, and is probably either oligoclase or albite. The quartz is remarkable, it occurs in rather irregular streaks formed of aggregated granules of varied size and rather irregular outline, 'clotted' together in a way that is common in mica schists. I never saw this structure in a rock that had indubitably consolidated from a state of fusion; yet the felspars, by their form and general aspect, suggest an igneous origin. They give, however, indications of fracture, so that I am disposed to the opinion that the rock is a true diorite, but that the abnormal character of this specimen is due to local crushing, and subsequent cementation by infiltrated quartz.

Balgobach Hill. Dyke.—A dark felstone with light coloured felspar crystals of rather rounded form, and a crystal of black hornblende, the part remaining being about $\frac{1}{4}$ inch in diameter. Ground-mass crypto-

* Rosenbusch, *Mikros. Physi-gr.* Vol. II. p. 538, mentions the occurrence of Picotite in Picrite.

crystalline, pretty thickly studded with crystallites of felspar, hornblende (frequently belonitic) and filmy green minerals, sometimes rather ferrite-stained. Most of these appear to be hornblende, but some may be slightly altered magnesia mica or a chlorite. In the ground-mass are (1.) Crystals of felspar, often rather rounded externally. One or two may be orthoclase: most of them are certainly plagioclase, exhibiting zonal banding or polysynthetic twinning. With some hesitation I refer these to oligoclase; their worn and rounded aspect favours the idea that they were formed considerably anterior to the last consolidation of the rock. (2.) Hornblende. Most of this occurs in crystals from about .01 to .02 inch diameter, sometimes showing the characteristic external form and prismatic cleavage, sometimes rather fibrous in structure. The larger crystal of hornblende mentioned above is included in the slide, and proves to be a group of four. These contain as interpositions, magnetite, apatite, biotite, and several rounded grains of plagioclase felspar. The last occur similarly to the olivine grains in the larger augite or hornblende crystals of a picrite. So far as my experience goes, these felspar interpositions are not very common. There is some apatite and several grains of iron peroxide, probably magnetite (one exhibiting a skeletal structure) in the slide. There is no appreciable amount of free quartz in the slide, so that the rock must be named a porphyrite.

From a Lava Stream, Gipps Land.—A compact dark rock, with very faint indications of a fluidal structure and some small whitish felspar crystals not exceeding $\frac{1}{8}$ th inch in diameter. The slide under the microscope shows a distinct fluidal structure, and when examined with a $\frac{1}{8}$ th objective exhibits a clear glassy base crowded in part with minute granules and trichites of opacite and ferrite, and with other microliths too small to be determined. In this matrix are embedded fragments of lava, presenting various slight structural or mineral differences, together with several small felspar crystals, often rather rounded in outline, which contain glass inclusions; generally the mineral is rather decomposed. The majority are orthoclase, but one or two show plagioclastic twinning. In parts of the slide small grains of clear quartz are rather frequent. The rock then is a rhyolite, probably with a considerable percentage of iron and a not very high one of silica.

Omeo, Victoria Plains, running in Dykes through the Country.—A buff-coloured felstone, consisting of a somewhat granular intimate mixture of quartz and rather decomposed felspar, with crystals of quartz (bipyramidal) and decomposed felspar (small). Under the microscope the ground-mass exhibits a cryptocrystalline structure approximating to micrographic or

spherulitic, fairly perfect spherulites appearing in parts of the slide; these, however, have no definite boundaries, but are confusedly intergrown (see Daubrée, *Geol. Exper.* Vol. I. p. 170, fig. 45). A few small scales of a colourless mica are scattered about. Some of the quartzes contain a fair number of cavities (exhibiting in one or two a linear arrangement). These are often empty and stained, but some contain fluid with rather small bubbles, others are very clear. There are enclosures of ground-mass. The feldspars are rather decomposed, but plagioclase as well as orthoclase is present. There are some scales of a dirty brown mica, probably lepidomelane, with opacite and ferrite. The rock accordingly is a typical quartz-felsite (quartz-porphyry of many authors).

From the same Locality and from a parallel Dyke.—A somewhat similar rock to the last described, but rather more compact and without quartz or feldspar readily visible to the eye. A little yellower in colour. The microscopic structure presents a general similarity, but is rather more definitely spherulitic. There are numerous small irregularly shaped grains of pretty clear quartz, often clustered, but none of conspicuous size, and no isolated feldspar crystals. The same mica as in the other slide. Also a quartz felsite.

Mount Pleasant. Part of the Sisters, Omeo.—A very pretty fairly compact felstone of pinkish grey colour, containing darkish bipyramidal quartz and light reddish feldspar crystals up to about .2" diameter. Under the microscope the ground-mass exhibits a minute microcrystalline structure, and evidently is largely composed of feldspar, which is decomposed and ferrite-stained. The larger feldspar crystals also are much decomposed; so far as I can ascertain they are orthoclase. Microlithic enclosures and cavities are rather abundant in the quartzes; the latter usually containing bubbles which vary from about $\frac{1}{4}$ th to $\frac{1}{2}$ th of the total volume. The rock, like the last, is a quartz-felsite.

Tasmania.—Small fragments of a blackish serpentine containing very typical bastite. I have given so many descriptions of the structure of serpentine that it is only needful to say this is a good example of an altered olivine rock, of which mineral indeed a few small 'kernels' still remain in one corner of the slide; the black 'strings' are stronger in one direction than in that transverse to it, and are very rudely parallel, from which I infer a slight tendency to a banding in the original rock. Next to the strings comes a zone of nearly colourless serpentine, with a clearly marked fibrous structure at right angles to the strings, and within this is a greener serpentine, of less definite structure. There is a fair amount of enstatite, more or less converted into a serpentinous mineral, but still retaining indications of its

cleavage structures, and generally free from iron stains; but in one place what may have been an enstatite crystal is almost wholly replaced by iron peroxide, and with it two or three grains (which apparently consolidated after the olivine and enstatite) of a closely cleaved rather dirty looking mineral, which from its extinction angle is clearly diallage. As usual, a few large grains of magnetite are scattered about. The rock then has been an enstatite-diallage-peridotite.

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The Crystallography of Bournonite.

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Museum.

[Read June 24th, 1884.]

LITERATURE.

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|------------|-------|--|
| Rashleigh, | 1797. | Specimens of British Minerals, Plate XIX.
p. 84. . |
| Bournon, | 1804. | Philosophical Transactions, p. 80. |
| Smithson, | 1808. | Philosophical Transactions, p. 55. |
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| Phillips, | 1821. | Annals of Philosophy, Vol. XVIII. p. 860. |
| Haüy, | 1822. | Traité de Minéralogie, IV. p. 295. . |
| Haüy, | 1822. | Traité de Crystallographie, p. 489. |
| Phillips, | 1823. | Elementary Introduction to Mineralogy, p. 886. |
| Mohs, | 1824. | Grundriss der Mineralogie, II., p. 561. |
| Dufrénoy, | 1836. | Annales des Mines (III.), Tome X. p. 871. |
| Lévy, | 1837. | Description d'une Collection de Minéraux, II.
p. 406. |
| Mohs, | 1839. | Naturgeschichte des Mineralreichs, II. p. 531. |

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Hausmann,	1847.	Handbuch der Mineralogie (II. Theil), I. p. 171.
G. Rose,	1849.	Poggendorf's Annalen, LXXVI. p. 291.
Brooke and Miller,	1852.	Phillips's Mineralogy, p. 201.
Kenngott,	1854.	Sitzungsberichte der k.k. Akad. Wien. XIII. p. 431.
Dufrénoy,	1856.	Traité de Minéralogie, III. p. 289.
Greg and Lettsom,	1858.	Manual of Mineralogy, p. 844.
Zirkel,	1862.	Sitzungsberichte der k.k. Akad. Wien. XLV. (1.) p. 431.
Hessenberg,	1863.	Mineralogische Notizen, V. p. 82.
Zepharovich,	1865.	Sitzungsberichte der k.k. Akad. Wien. LI. (2.) p. 108.
Schrauf,	1872.	Atlas der Krystall-formen des Mineralreiches, IV. Taf. XXXVI.
Sadebeck,	1876.	Angewandte Krystallographie, p. 120.
Zepharovich,	1876.	Lotos. (Neues Jahrbuch, p. 555.)
Quenstedt,	1877.	Handbuch der Mineralogie, p. 889.
Vom Rath,	1877.	Zeitschrift für Krystallographie u. Mineralogie, I. p. 602.
Groth,	1878.	Die Mineraliensammlung der Kaiser Wilhelms Univ., Strassburg, p. 61.
Kokscharow,	1882.	Materialien zur Mineralogie Russlands, VIII. p. 123.

The above table is a list of all publications which contain original crystallographic work, observations, or figures relating to Bournonite; it omits the names of many other works which mention the mineral, but merely contain information compiled from earlier sources; and it refers only to such works as are concerned with the crystalline form. The complete history of the crystallography of Bournonite will therefore be found in the above publications. The most important and comprehensive of these is the monograph of Zirkel published in 1862; this paper contains a summary of the previous literature and the results of many new observations, together with a large number of new figures. There is, however, a serious omission in the review of the earlier literature; no notice is taken of the earliest accurate observations made upon the mineral by W. Phillips in 1821; and it will be found that this omission leads to several errors in Prof. Zirkel's summary of previous crystallographic work, which will be mentioned in detail below.

Since the appearance of Zirkel's memoir the following authors have written :—Hessenberg on twin crystals, and new forms ; Schrauf, figures and a new form ; Zepharovich, on two new forms from Przibram ; Vom Rath on the combination of crystals from Nagyag ; Groth, a new form from Horhausen ; Kokscharow, measurement of two crystals from Neudorf.

The observations contained in the present paper are the result of a study of the collection of Bournonite in the British Museum, which is particularly rich in splendid specimens from Wheal Boys and Herodsfoot Mine in Cornwall, and contains also many fine examples from other localities, especially Neudorf, Horhausen, and Kapnik.

Figures 2 and 3 represent the general form of crystals from Endellion and Liskeard, and may be added to the numerous figures of Lévy, Zirkel, and Schrauf ; while the paper may be regarded as an appendix to the monograph of Zirkel.

Forms.—The latest complete list of observed forms is that given by Hessenberg, who mentions 48. This contains the 40 given in the table of Zirkel, and in addition 8 determined by himself. Since that time two have been observed by Zepharovich, one by Schrauf, and one by Groth. The table given by Zirkel contains 29 forms recorded by previous observers. In this table, however, as is shown below, four of Hausmann's forms and two of Mohs' are wrongly quoted, while two given by Mohs are omitted. Since in addition to this Hausmann himself was led into error in interpreting the measurements given by Phillips in 1828, it follows that these tables must be considerably modified.

It will be found that the only observations of much independent value are those of Phillips, Mohs, and Hausmann.

The measurements of Bournon were made before the reflecting goniometer had come into use, and are totally unreliable.

Those of Phillips given in 1821 are observations made upon 16 crystals with the reflecting goniometer, and those which he gives in his *Mineralogy* in 1828 are doubtless the result of further work. The work of Mohs appears to be quite independent ; Hausmann had seen the results both of Mohs and Phillips, but adds forms of his own determination. Most other tables of forms are copied from Mohs (Hartmann's, for example), with the exception of Dufrénoy's in 1856, which is unintelligible as it stands, and which is criticised below.

The following table gives a complete list of the 50 forms hitherto established, with their first observers, and at the same time a comparison between the forms of Phillips, Mohs, and Hausmann.

These refer to the editions of 1828, 1889, and 1847 respectively.

			Phillips.	Mohs.	Hausmann.	
<i>a</i>	100	$\infty \bar{P} \infty$		$(\bar{P}r + \infty)s$	<i>B</i>	
<i>b</i>	010	$\infty \bar{P} \infty$	<i>M</i>	$(P - \infty)k$	<i>B'</i>	
<i>c</i>	001	0 <i>P</i>	<i>P</i>	$(\bar{P}r + \infty)r$	<i>A</i>	
<i>r</i>	0 1 13	$\frac{1}{13} \bar{P} \infty$	<i>b</i> ₁		<i>AB' 13</i>	
<i>β</i>	018	$\frac{1}{8} \bar{P} \infty$	<i>c</i> ₁		<i>AB 8</i>	
<i>t</i>	014	$\frac{1}{4} \bar{P} \infty$				Miller.
<i>ψ</i>	027	$\frac{2}{7} \bar{P} \infty$	<i>b</i> ₂		<i>AB' 7</i>	
<i>e</i>	013	$\frac{1}{3} \bar{P} \infty$				Hessenberg.
<i>x</i>	012	$\frac{1}{2} \bar{P} \infty$	<i>b</i> ₃	$(\bar{P}r) p$	<i>AB' 2</i>	
<i>h</i>	023	$\frac{2}{3} \bar{P} \infty$		$\frac{2}{3} \bar{P}r$		
<i>ν</i>	084	$\frac{4}{8} \bar{P} \infty$			<i>AB' 4</i>	
<i>o</i>	011	$\bar{P} \infty$	<i>b</i> ₄ (<i>c</i> ₂)	$(Pr - 1)o$	<i>D'</i>	
<i>σ</i>	064	$\frac{4}{6} \bar{P} \infty$			<i>B' 4</i> $\frac{2}{3}$	
<i>z</i>	021	$\frac{2}{2} \bar{P} \infty$	<i>b</i> ₅		<i>B' 4</i> $\frac{1}{2}$	
<i>δ</i>	081	$\frac{8}{8} \bar{P} \infty$				Zirkel.
<i>ζ</i>	041	$\frac{4}{4} \bar{P} \infty$				Hessenberg.
<i>η</i>	130	$\infty \bar{P} 3$				Hessenberg.
<i>e</i>	120	$\infty \bar{P} 2$	<i>d</i> ₃	$(\bar{P}r - 1)e$	<i>B' B 2</i>	
<i>l</i>	230	$\infty \bar{P} \frac{2}{3}$	<i>d</i> ₂		<i>B' B</i> $\frac{3}{2}$	
<i>θ</i>	340	$\infty \bar{P} \frac{4}{4}$				Hessenberg.
<i>k</i>	450	$\infty \bar{P} \frac{4}{5}$				Zirkel.
<i>m</i>	110	∞P	<i>d</i> ₁	$(\bar{P}r)d$	<i>E</i>	
<i>w</i>	430	$\infty \bar{P} \frac{4}{3}$				Miller.
<i>a</i>	320	$\infty \bar{P} \frac{3}{2}$			<i>BB' 3</i>	
<i>f</i>	210	$\infty \bar{P} 2$		$(\bar{P}r + 1)f$	<i>BB' 2</i>	
<i>i</i>	310	$\infty \bar{P} 3$				Zirkel.
<i>d</i>	610	$\infty \bar{P} 6$				Zirkel.
<i>Σ</i>	301	$\frac{3}{3} \bar{P} \infty$				Schrauf.
<i>n</i>	101	$\bar{P} \infty$		$(\bar{P} + \infty)^2 n$	<i>D</i>	
<i>γ</i>	203	$\frac{2}{3} \bar{P} \infty$			<i>AB 3</i>	
<i>κ</i>	103	$\frac{1}{3} \bar{P} \infty$				Hessenberg.
<i>g</i>	221	$\frac{2}{2} P$				Zirkel.
<i>μ</i>	332	$\frac{3}{3} P$				Hessenberg.
<i>χ</i>	334	$\frac{3}{4} P$			<i>AE 4</i>	
<i>y</i>	111	<i>P</i>	<i>a</i> ₆	$(\bar{P}r - 1)^2 = (\bar{P} - 1)^2 y$	<i>P</i>	
<i>p</i>	223	$\frac{2}{3} P$			<i>AE 3</i>	
<i>u</i>	112	$\frac{1}{2} P$	<i>a</i> ₁ (<i>a</i> ₂)	<i>P</i>	<i>AE 2</i>	
<i>φ</i>	113	$\frac{1}{3} P$				Zirkel.
<i>v</i>	121	$\frac{2}{2} \bar{P} 2$	<i>a</i> ₅ ?			
<i>s</i>	122	$\bar{P} 2$	<i>a</i> ₇ ?	<i>P - 1</i>		
⊙	123	$\frac{2}{3} \bar{P} 2$	<i>a</i> ₃ ?	$(\bar{P} - 1)^{\frac{2}{3}} = (\bar{P}r - 2)^{\frac{2}{3}}$		
<i>ξ</i>	124	$\frac{1}{2} \bar{P} 2$		$(\bar{P} - 1)^2$		
<i>ω</i>	436	$\frac{4}{3} \bar{P} \frac{4}{3}$				Zirkel.
<i>ρ</i>	211	$\frac{2}{2} \bar{P} 2$				Zirkel.
<i>π</i>	212	$\bar{P} 2$				Zirkel.
<i>r</i>	314	$\frac{3}{4} \bar{P} 3$				Miller.
<i>λ</i>	414	$\bar{P} 4$				Zirkel.
<i>G</i>	236	$\frac{2}{3} \bar{P} \frac{2}{3}$				Zepharovich.
⊖	136	$\frac{1}{3} \bar{P} 3$				Zepharovich.
<i>Δ</i>	4 7 14	$\frac{4}{7} \bar{P} \frac{4}{7}$				Groth.

The above table requires several explanatory remarks. The figure in Phillips's *Mineralogy*, reproduced here in fig. 1, evidently represents a twin crystal, which he did not recognise as such; for the angle $c_2 : b_4$ is $60^\circ 38'$ (instead of $58^\circ 28'$ as calculated from the values which he gives for Pb_4 and Pc_2), and is the angle $oo_1 = 60^\circ 32'$ across the twin plane of junction. A simple juxtaposition twin crystal is shown for comparison in fig. 4 (Hessenberg's fig. 31), in which $bb_1 = 98^\circ 40'$, $uu_1 = 4^\circ 0'$, $mm_1 = 7^\circ 20'$, $oo_1 = 60^\circ 32'$. The angles given in Phillips's *Mineralogy* represent actual measurements, as he is careful to state, and are not the result of any calculation; and the angles given for Bourmonite are probably those obtained from the actual crystal there figured. In his paper of 1821 in *Nicholson's Journal*, the only measurements given are those which relate to the forms $a b c m o u$; and it appears that there also only twin crystals had been examined, for the angles $001 : 011$ and $001 : 101$ (P^1b and P^1a) are given as $48^\circ 12'$ and $48^\circ 44'$ respectively, and these both denote co .

Hence, interpreting Phillips's figure as a twin crystal, it will be seen that a_1 and a_2 are both u faces ($a_1 a_2 = 4^\circ 50'$), d_1 and d_4 are both m faces, and c_2 and b_4 are both o planes. Then b_1 is (0 1 18) and c_1 is (018). Now these two are evidently the origin of Hausmann's (0 1 18) and (108), while c_2 is probably the origin of his (12 0 11), since $(001) : (12 0 11)$ is $48^\circ 35'$ with Hausmann's elements, and $P : c_2 = 48^\circ 51'$ (Phillips). Hausmann's (027) is then Phillips's b_2 .

Phillips's a_3 and a_7 are probably v and s . It seems that he occasionally confuses the a_1 and a_2 of his figure, and if this is the case, a_3 may be referred to the form $\odot$, and a_4 (distant $3^\circ 45'$ from c_2) possibly to (1 11 11) given below as N . To the face a_6 , which makes an angle of only $0^\circ 36'$ with u , definite indices can hardly be assigned. Except for the confusion between a_1 and a_2 , Phillips's measurements are no doubt accurate, and lead to nearly the same elements as those of Miller; but it is impossible that $MT = 90^\circ$, and there may also be a confusion between d_1 and d_4 .

The table of Mohs represents his independent investigations, which are the earliest that recognise the twinning, and therefore lead to elements that are nearly correct.

NOTE TO TABLE ON p. 62.—In the Manuscript Catalogue of the Allan-Greg Collection (earlier than 1826) Haidinger figures g ($\bar{P}-2$)⁴ and z ($\bar{P}r-2$) as occurring on crystals from Servoz, with $\{\frac{1}{2}\bar{P}-4\}$ ¹² = (661) between my and $(\bar{P}r+2)$ ⁵ between uc in the zone $[cum]$. Also $(\bar{P}r-1)$ ⁵ from Cornwall between uy . Perhaps this should be $(\bar{P}r-1)$ ⁷ = p .

Hausmann calculates his elements from the observed angles $\chi\chi'$ and mm' . With his parameters Phillips's b_1, c_1, c_2, b_2 correspond to forms $\{0\ 1\ 18\}$ $\{108\}$ $\{12\ 0\ 11\}$ $\{027\}$ if the twinning be overlooked, so that Phillips's zone PT corresponds to Hausmann's AB . To these forms accordingly Hausmann assigns the above faces. As regards his own elements, it is impossible that the face χ can have been observed so well-developed as to be chosen for a parametral face. There may therefore have been, as has frequently been the case, a confusion between the zones cm and cb , for $m\chi = 46^\circ 15' = bo$ nearly. His faces $\nu\ \sigma\ a\ \gamma$ are here retained because the angles given for them (though calculated from his elements) must represent some measured angles, and there are no forms to which they approximate more nearly than those to which he ascribes them; $AB\frac{1}{2} = (804)$ and $B'A\frac{1}{2} = (075)$ are probably u and y .

The comparative table given by Zirkel, p. 442, contains several errors. Thus Hausmann's forms $\{108\}$ $\{208\}$ $\{804\}$ are wrongly given as $\{801\}$ $\{802\}$ $\{408\}$. Hausmann's $\{12\ 0\ 11\}$ is referred to $\{11\ 0\ 12\}$. Mohs' $\frac{1}{2}\bar{P}r$ is ascribed to the form $\{480\}$ instead of $\{028\}$. $(P-1)^3$ is ascribed to the form $\{121\}$ instead of $\{124\}$, while $(P-1)$ and $(\bar{P}-1)\frac{1}{2}$ are omitted.

These errors are copied into Hessenberg's table. The forms $\odot$ and ξ , given as new by Hessenberg, had therefore been already detected by Mohs. The form Σ is given as new by Vom Rath (N) in 1877, but it had been previously given by Schrauf, Taf. 87, fig. 17.

Of the above forms $\psi h\nu\sigma\eta\alpha\beta\gamma\chi r$ are rejected by Schrauf.

Of these, however, $h\eta\gamma\alpha\chi$ have been observed by myself, $\psi\nu\sigma\beta$ are supported by Phillips's measurements, ψ and σ by Dufrénoy's, and r is given by Miller. Zirkel's face q [311] is here rejected on Schrauf's authority. (See Zirkel, fig. 84, and compare Schrauf's preliminary remarks on *Bourbonite*.)

There only remains the somewhat elaborate table of forms given with measurements by Dufrénoy in his *Traité de Minéralogie*. This table, which is unintelligible as it there stands, is partly explained by his original memoir in the *Annales des Mines*, which is not mentioned by Zirkel. It will be seen from that memoir that Dufrénoy, like many of the earlier observers, took twin crystals for simple individuals, and also confused the zones $[bc]$ and $[mc]$; the zone $[an]$ he does not appear to have observed at all.

His statement that there are no angles common to the crystals from

Cornwall and Alais is enough in itself to show that there had been some confusion.

His table of measurements (uncorrected by calculation) is not quite intelligible, but the results may most probably be interpreted by the aid of the following table, in which the letters are those used in the original memoir, and not those of the transcript in the *Traité de Minéralogie*, where there are several misprints.

	Alais.	Oberlahr.	Pontgi- band.	Cornwall.	Kapnik.	Servoz.
<i>b</i>				<i>MT</i>	<i>T</i>	
<i>c</i>	<i>P</i>	<i>P</i>	<i>P</i>	<i>P</i>	<i>P</i>	<i>P</i>
<i>o</i>	<i>a</i>	<i>a</i>	<i>a</i>	<i>b₄ c₂</i>		<i>c₂</i>
<i>u</i>	<i>cb</i>		<i>cb</i>	<i>a₁</i>		<i>a₁</i>
<i>y</i>	<i>bg</i>	<i>b</i>	<i>b</i>			
<i>m</i>	<i>MT</i>		<i>MT</i>	<i>d₁</i>	<i>d₁</i>	
β				<i>e₁</i>		
ψ				<i>b₂</i>		
σ		<i>f</i>			<i>f</i>	

Here the first column denotes the forms to which the faces mentioned in Dufrénoy's table of measurements are probably to be ascribed.

Finally, the crystal of Wölchite described by Kenngott in 1854, and explained by Zepharovich in 1865 as a simple individual and a combination of the forms *cabm* (304) and (705), may be in reality a twin crystal of the combination *camuy*; since approximate measurements gave $oP : m\check{P}\infty = 83\frac{1}{2}^\circ (=cu)$ and $\infty\check{P}\infty : m\check{P}\infty = 89^\circ (?) (=my)$.

To the above list of 50 forms must now be added 29 new forms, about which there can be no doubt, which are given in the first of the two following tables; while the second table contains 21 forms of which isolated faces have been observed, but which are not free from suspicion.

TABLE I.

Δ	015	$\frac{1}{2} \bar{P} \infty$	S	559	$\frac{5}{8} P$
F	025	$\frac{3}{8} \bar{P} \infty$	E	558	$\frac{5}{8} P$
R	570	$\infty \bar{P} \frac{7}{8}$	K	554	$\frac{5}{8} P$
Π	8 11 0	$\infty \bar{P} \frac{11}{8}$	Z	443	$\frac{5}{8} P$
M	790	$\infty \bar{P} \frac{7}{8}$	θ	17 17 12	$\frac{11}{12} P$
Ψ	650	$\infty \bar{P} \frac{5}{8}$	Γ	885	$\frac{5}{8} P$
Ξ	10 3 0	$\infty \bar{P} \frac{10}{8}$	Y	535	$\frac{5}{8} \bar{P} \frac{5}{8}$
Φ	410	$\infty \bar{P} \frac{4}{8}$	D	232	$\frac{3}{8} \bar{P} \frac{3}{8}$
L	510	$\infty \bar{P} \frac{5}{8}$	V	544	$\frac{5}{8} \bar{P} \frac{5}{8}$
N	1 11 11	$\bar{P} 11$	Q	322	$\frac{3}{8} \bar{P} \frac{3}{8}$
ν	2 7 14	$\frac{1}{2} \bar{P} \frac{7}{8}$	X	473	$\frac{3}{8} \bar{P} \frac{7}{8}$
U	134	$\frac{1}{4} \bar{P} \frac{3}{8}$	T	231	$\frac{3}{8} \bar{P} \frac{3}{8}$
I	213	$\frac{3}{8} \bar{P} 2$	W	341	$\frac{4}{8} \bar{P} \frac{3}{8}$
Ω	114	$\frac{1}{4} P$	H	725	$\frac{7}{8} \bar{P} \frac{1}{8}$
P	10 10 19	$\frac{10}{19} P$			

TABLE II.

097	$\frac{9}{7} \bar{P} \infty$	20 20 21	$\frac{20}{21} P$
160	$\infty \bar{P} 6$	18 1 19	$\frac{18}{19} \bar{P} 18$
13 6 0	$\infty \bar{P} \frac{13}{6}$	10 1 9	$\frac{10}{9} \bar{P} 10$
16 5 0	$\infty \bar{P} \frac{16}{5}$	20 19 38	$\frac{19}{38} \bar{P} \frac{19}{38}$
720	$\infty \bar{P} \frac{7}{2}$	11 22 34	$\frac{11}{34} \bar{P} 2$
580	$\infty \bar{P} \frac{5}{8}$	1 0 14	$\frac{1}{14} \bar{P} \infty$
850	$\infty \bar{P} \frac{8}{5}$	638	$\frac{1}{2} \bar{P} 2$
910	$\infty \bar{P} 9$	12 12 11	$\frac{12}{11} P$
17 17 11	$\frac{17}{11} P$	312	$\frac{3}{2} \bar{P} 3$
14 14 11	$\frac{14}{11} P$	104	$\frac{1}{4} \bar{P} \infty$
445	$\frac{4}{5} P$		

Parameters.—The axial lengths deduced by the earlier observers from their measurements are criticised by Zirkel.

Expressed in terms of the elementary angles *bo*, *cn*, *am*, the elements of Bournonite as determined by the only authors who have published original observations are :

		010 : 011	001 : 101	100 : 110
Phillips	...	46°48'	48°44'	46°45'
Haüy	...	44·28	44·29	46·4
Mohs	...	46·26	41·44 $\frac{1}{2}$	46·50
Lévy	...	46·28	41·42	46·50

	010 : 011	001 : 101	100 : 110
Hausmann ...	47·8	41·8	46·50
Miller ...	46·17	41·58½	46·50
Dufrénoy, 1856	46·48	81·82	46·50
Zirkel ...	46·19	41·57	46·44½

The early determinations of Bournon with the hand goniometer are valueless. Lévy (probably), Glocker, Dana, Naumann, and Quenstedt, in editions previous to 1852, copy Mohs; Beudant takes the angles from Phillips; and since 1852 the elements of Miller have usually been adopted.

It has been pointed out above that Phillips's angles are based upon a twin crystal, and that Hausmann's elements are probably to be traced to a confusion between α and χ .

The elements of Mohs given above are reduced to Hausmann's and Miller's axes; those of Dufrénoy are deduced from his primitive form, which is totally wrong and due to a confusion of the zones cb and cm , so that they involve very cumbersome indices even for the faces which he gives. He is wrong in stating that Lévy's primitive form is erroneous.

Haüy refers Bournonite to the same parameters as Stibnite; but his conclusion is only based on the measurement of two faces which make angles of 57° and 38° respectively with the basal plane.

The measurement of a large number of crystals with the view of ascertaining if possible how far the elements vary with the locality or the composition, has led to the belief that the parameters deduced from the best measurements upon several crystals from the same locality, or even from the same specimen, are almost exactly those of Miller. On the other hand, the angles between pairs of individual faces upon a crystal may often differ by as much as 20 minutes from the theoretical value, and individual crystals seem occasionally to require parameters differing to a slight extent from those here adopted.

But as these variations are not consistent, but are characteristic only of particular isolated faces, or at the most of particular crystals, it is very difficult to determine satisfactory parameters for any given crystal, and impossible to find any regularity in their variations. The only law observed is that while the angles in the prism zone $[amb]$ are remarkably constant (as is also indicated by the close agreement of the elementary angle of previous observers in this zone), other zones, and especially the vertical zones $[cob]$ $[cum]$ $[cna]$, are occasionally contracted or expanded, pointing to a slight increase or decrease in the vertical axis.

The elementary angles here adopted are—

$$bo=46^{\circ}17', cn=41^{\circ}58', am=46^{\circ}50';$$

corresponding to the axial ratios $a : b : c = 1.06612 : 1 : .95618$.

Since the table of calculated angles given by Zirkel (which is the only one of any importance yet given for Bournonite) contains 43 errors which are too large to be neglected, it has been thought advisable to give the following list of over 1,000 angles. Most of these have been calculated in two ways—(1) by the methods of spherical trigonometry, (2) by the general formula for the angle between any two faces in terms of the parameters, and the indices. (See Brezina, *Krystallographische Untersuchungen*, I. p. 806.)

It is hoped that in this way errors have been avoided. (See pp. 69-70.)

Measurements.—It will be necessary to give the measurements by which the faces of Table I. have been established, and those of Table II. supported.

∇ on a crystal from Endellion— $o\nabla=33^{\circ}7'$, $ox=18^{\circ}11'$ or $18^{\circ}20'$.

F and Y on a crystal from Herodsfoot Mine with *bofvsxone*.

F between x and ε , $xF=4^{\circ}59'$ Y in the zone $s\chi$, $sY=28^{\circ}29'$.

$$x\varepsilon=7^{\circ}49'$$

$$bY=67^{\circ}2'.$$

ΠRM on a crystal from Herodsfoot Mine with *bmθel*—

$$bR=83^{\circ}19' \quad b\Pi=84^{\circ}80' \quad bM=85^{\circ}52'.$$

Π on another crystal from the same specimen, $b\Pi=84^{\circ}21'$.

R (two faces) on a crystal from Braunsdorf with *cumoazevbn*—

$$mR=9^{\circ}4', mR' (=110 : \bar{5}70) = 77^{\circ}14'.$$

Ψ on a crystal from Herodsfoot Mine with *blθmaf* and perhaps (580) and (850), $b\Psi=48^{\circ}21'$; $b : 530=57^{\circ}16'$; $b : 850=56^{\circ}34'$.

Ψ on a crystal from Herodsfoot Mine with *blθkmafi* Φ , $b\Psi=48^{\circ}40'$.

* $\mathbb{E}$ on a crystal from Endellion with *cuoy nabefmwia p* Σ . There are two faces of the form, $a\mathbb{E}=17^{\circ}58'$, $a\mathbb{E}'=17^{\circ}27'$

Φ on a great number of crystals from Herodsfoot Mine.

RLI on a crystal from Herodsfoot Mine with *bousynpnef* Φ , and traces of (104), $bR=33^{\circ}51'$, $bL=77^{\circ}59'$, $oI=88^{\circ}48'$, $ou=28^{\circ}16'$, $on=58^{\circ}30'$, $a : 104=77^{\circ}22'$. I is a fair sized face between *un*.

N on a crystal from Herodsfoot Mine with *bosy p* $\odot\xi mfi$ Φ and perhaps a face (11 22 34). N is a slightly rounded face between *os*; and (11 22 34) lies between $\odot\xi$ in the zone $es\odot\xi$.

$$sN=14^{\circ}84', so=18^{\circ}8', s : (11 \ 22 \ 34)=12^{\circ}8', s\xi=18^{\circ}41', s\odot=11^{\circ}8'.$$

v on several crystals from Herodsfoot Mine, $bv=64^{\circ}19'$, $uv=15^{\circ}26'$, are the measurements on one crystal.

* This is from one of the two specimens figured in Rashleigh's Plate XIX., the earliest described specimen of Bournonite.

		<i>a.</i>	<i>b.</i>	<i>c.</i>	<i>o.</i>	<i>m.</i>	<i>n.</i>	<i>y.</i>	<i>u.</i>	<i>s.</i>	<i>x.</i>	<i>e.</i>	<i>l.</i>
0 1 13	τ	90°0	85°48	4°12	39°81	86°56	42°4	49°39	30°18	42°47	21°21	86°12	86°26
018	β	90°0	83°11	6°49	36°54	85°2	42°21	47°51	28°37	40°28	18°44	83°50	84°18
015	∇	90°0	79°10	10°50	32°53	82°7	43°2	45°12	26°18	36°58	14°43	80°12	80°50
014	ϵ	90°0	76°33	13°27	30°16	80°14	43°37	43°33	25°0	84°35	12°6	77°51	78°37
027	ψ	90°0	74°43	15°17	28°26	78°55	44°6	42°27	24°12	33°14	10°16	76°12	77°5
013	ϵ	90°0	72°19	17°41	26°2	77°12	44°49	41°4	23°20	31°16	7°52	74°2	75°5
025	F	90°0	69°4	20°56	22°47	74°54	45°57	39°19	22°29	28°43	4°37	71°8	72°22
012	x	90°0	64°27	25°33	18°10	71°40	47°49	37°8	22°2	25°20	51°6	67°1	68°33
023	h	90°0	57°29	32°31	11°12	66°55	51°7	34°36	23°3	21°4	6°58	60°53	62°53
034	ν	90°0	54°21	35°39	8°4	64°51	52°47	33°49	24°8	19°37	10°6	58°9	60°23
011	o	90°0	46°17	43°43	87°26	59°44	57°27	32°57	28°16	17°57	18°10	51°16	54°8
054	σ	90°0	39°55	50°5	6°22	55°59	61°28	33°30	32°31	19°1	24°32	46°1	49°26
021	ρ	90°0	27°36	62°24	18°41	49°44	69°50	37°21	42°7	25°41	36°51	36°39	41°17
031	δ	90°0	19°13	70°47	27°4	46°28	75°49	41°39	49°15	32°6	45°14	31°16	36°48
041	ζ	90°0	14°39	75°21	31°38	45°7	79°9	44°24	53°15	35°55	49°48	28°51	34°53
130	η	72°38	17°22	90°0	48°44	25°48	78°30	44°17	60°25	43°59	65°41	7°46	14°39
120	e	64°52	25°8	90°0	51°16	18°2	73°31	40°53	58°35	43°26	67°1	50°16	6°53
230	l	57°59	32°1	90°0	54°8	11°9	69°16	38°44	57°27	43°52	68°33	6°53	64°2
570	R	56°11	33°49	90°0	54°57	9°21	68°11	38°19	57°15	44°7	69°0	8°41	1°48
8 11 0	Π	56°42	34°18	90°0	55°11	8°52	67°54	38°13	57°12	44°12	69°8	9°10	2°17
840	θ	54°53	35°8	90°0	55°35	8°2	67°24	38°4	57°7	44°21	69°20	9°59	3°6
790	M	53°53	36°7	90°0	56°4	7°8	66°49	37°54	57°2	44°32	69°37	10°59	4°6
450	k	53°7	36°53	90°0	56°27	6°17	66°22	37°47	56°59	44°41	69°49	11°45	4°52
110	m	46°50	43°10	90°0	59°44	86°20	62°49	37°20	56°45	46°20	71°40	18°2	11°9
650	ψ	41°37	48°23	90°0	62°41	5°13	60°3	37°39	56°54	48°9	73°21	23°15	16°22
430	w	38°39	51°21	90°0	64°26	8°11	58°34	38°6	57°8	49°21	74°22	26°13	19°20
320	a	35°24	54°36	90°0	66°24	11°26	57°1	38°48	57°30	50°47	75°32	29°28	22°36
210	f	28°4	61°56	90°0	71°2	18°46	53°54	41°10	58°44	54°27	78°18	36°48	29°55
810	i	19°34	70°26	90°0	76°37	27°16	51°0	45°2	60°50	59°17	81°42	45°18	38°25
10 3 0	Φ	17°44	72°16	90°0	77°51	29°6	50°30	46°0	61°22	60°24	82°27	47°8	40°16
410	Φ	14°56	75°4	90°0	79°44	31°54	49°49	47°33	62°16	62°8	83°37	49°56	43°3
510	L	12°2	77°58	90°0	81°43	34°48	49°13	49°14	63°15	63°58	84°50	52°50	45°57
610	d	10°5	79°55	90°0	83°3	36°45	48°53	50°25	63°56	65°15	85°40	54°47	47°54
301	Σ	20°23	90°0	69°37	75°25	50°7	27°44	43°51	49°59	58°5	71°41	66°32	60°12
101	n	48°7	90°0	41°53	57°27	62°49	83°46	35°27	29°12	44°8	47°49	73°31	69°16
203	γ	59°7	90°0	30°53	51°40	69°27	11°1	36°54	24°35	41°37	39°16	77°24	74°13
103	κ	73°21	90°0	16°39	46°10	78°42	25°15	42°32	24°32	41°35	30°8	83°1	81°16
114	Ω	77°42	76°52	18°9	32°27	71°51	31°49	34°31	15°6	29°44	17°12	72°46	72°12
113	ϕ	74°6	73°1	23°36	30°13	66°24	30°7	29°4	9°39	24°69	17°42	67°37	66°52
112	u	67°58	66°26	39°15	28°16	56°45	29°12	19°25	66°30	17°32	22°2	58°35	57°27
10 10 19	P	67°8	65°31	34°37	28°13	55°23	29°18	18°8	1°22	16°40	22°54	57°18	56°8
559	S	66°15	64°34	36°4	28°14	53°56	29°28	16°36	2°49	15°26	23°52	55°57	54°43
558	E	64°18	62°28	39°20	28°32	50°40	30°5	13°20	6°5	14°12	26°12	52°56	51°33
223	p	63°15	61°19	41°9	28°51	48°51	30°33	11°31	7°54	13°55	27°35	51°15	49°47
334	x	61°20	59°15	44°31	29°41	45°29	31°40	8°9	11°16	13°36	30°15	48°11	46°32
111	y	57°3	54°33	52°40	32°57	37°20	35°27	74°40	19°25	15°0	37°8	40°53	38°44
554	K	54°16	51°29	58°37	36°13	31°23	38°57	5°57	25°22	18°56	42°24	35°44	33°7
443	Z	53°34	50°43	60°14	37°13	29°46	40°0	7°34	26°59	19°50	43°51	34°22	31°36
17 17 12	Θ	52°55	50°3	61°42	38°8	28°18	40°58	9°2	28°27	20°56	45°11	33°9	30°15
332	μ	52°26	49°27	63°3	39°1	26°57	41°53	10°23	29°48	22°1	46°25	32°3	29°0
885	Γ	51°52	48°49	64°31	40°0	25°29	42°54	11°51	31°16	23°12	47°46	30°52	27°40
221	g	50°16	47°2	69°8	43°14	20°52	46°12	16°28	35°53	27°7	52°1	27°19	23°33

		a.	b.	c.	o.	m.	n.	y.	u.	s.	x.	e.	l.
314	r	56.49	78.47	35.31	48.43	58.54	13.44	25.17	15.28	31.6	35.5	55.53	52.55
414	λ	48.55	79.54	42.52	49.23	54.43	10.6	25.21	21.38	34.44	42.31	64.2	60.11
213	I	60.20	74.42	34.7	38.40	57.55	18.47	22.26	10.24	26.27	30.86	63.19	60.55
725	H	40.43	76.36	52.42	53.2	46.24	16.25	23.40	27.46	36.31	49.27	57.48	53.8
2 7 14	v	83.24	64.38	26.20	19.20	66.58	41.56	31.18	15.26	21.3	6.36	64.7	64.54
136	Q	82.19	64.41	26.36	19.41	66.14	40.59	30.22	14.16	20.27	7.41	63.40	64.20
124	ξ	78.34	64.59	27.50	21.22	63.38	37.45	27.13	10.35	18.44	11.26	62.10	62.23
4 7 14	Δ	76.58	65.9	28.29	22.13	62.34	36.25	25.56	9.0	18.11	13.2	61.34	61.35
236	G	74.54	65.23	29.25	23.28	61.12	34.41	24.18	6.56	17.38	15.6	60.49	60.35
436	ω	61.39	67.41	37.26	33.16	53.1	24.45	16.16	6.19	19.38	28.21	56.57	55.0
212	π	51.1	70.24	45.28	42.23	47.33	19.36	15.51	16.57	26.17	38.59	55.11	51.50
535	Y	52.7	66.52	46.48	39.59	45.3	23.8	12.19	16.17	23.20	38.5	51.57	48.48
123	O	75.50	58.35	35.9	17.59	56.49	38.29	21.23	10.17	11.25	15.45	54.51	55.8
134	U	79.40	55.1	36.55	13.5	57.16	44.22	26.14	15.11	10.56	14.25	53.29	54.28
1 11 11	N	86.38	46.23	43.49	3.22	57.5	54.23	29.35	25.17	14.35	18.28	49.29	51.58
122	s	72.3	48.54	46.34	17.57	46.20	44.8	15.0	17.32	25.54	25.20	43.26	43.52
544	V	50.59	57.31	56.0	39.1	34.31	33.2	6.4	23.1	21.4	42.25	40.59	37.46
322	Q	45.48	60.18	58.47	44.12	33.3	31.39	11.15	26.45	26.15	47.4	41.53	37.51
211	ρ	37.39	65.2	63.48	52.21	31.50	30.59	19.24	33.23	34.24	54.31	44.4	38.57
232	D	62.51	43.7	59.24	29.17	32.23	46.53	11.26	27.18	13.58	39.17	31.17	30.36
121	v	67.26	35.5	64.40	28.59	30.45	54.55	19.28	34.0	18.6	42.21	25.20	26.11
473	X	63.56	34.56	68.27	33.41	26.3	55.29	20.25	36.2	22.2	46.45	21.45	21.52
231	T	59.27	35.36	73.32	39.56	19.48	56.36	23.4	41.10	27.36	52.40	17.49	16.28
341	W	55.46	36.54	77.56	45.16	14.28	57.53	26.16	45.12	32.38	57.45	15.37	12.27

	a.	b.	c.	m.	e.	l.
097	90.0	39.8	50.52	55.33	45.24	48.53
160	81.7	8.53	90.0	34.17	16.15	23.8
13 6 0	26.12	63.48	90.0	20.38	38.40	31.47
16 5 0	18.26	71.34	90.0	28.24	46.26	39.33
720	16.54	73.4	90.0	29.56	47.58	41.5
530	32.36	57.24	90.0	14.14	32.16	25.23
850	33.41	56.19	90.0	13.9	31.11	24.18
910	6.45	83.15	90.0	40.5	58.7	51.14
104	77.21	90.0	12.39	81.23	84.40	83.20
1 0 14	86.20	90.0	3.40	87.30	88.27	88.3
17 17 11	52.9	49.9	63.44	26.16	31.30	28.23
14 14 11	54.4	51.16	59.4	30.56	35.21	32.42
445	60.19	58.8	46.22	43.38	46.31	44.45
20 20 21	57.43	55.18	51.19	38.41	42.4	40.1
18 1 19	46.2	87.48	40.24	61.56	71.23	67.57
10 1 9	45.16	85.42	45.4	57.34	68.29	64.6
20 19 38	66.56	66.37	33.54	56.7	58.17	57.1
11 22 34	76.8	59.17	34.21	57.38	55.39	55.56
6 3 8	70.57	73.29	37.19	54.58	60.58	58.18
12 12 11	56.12	53.37	54.25	35.35	39.21	37.4
312	39.29	74.5	55.0	43.16	64.49	50.4

U on a crystal from the same specimen as the last, determined by the zones *bz* and *xs*; also on a crystal from Endellion, fig. 5, $oU=18^{\circ}6'$.

Ω on the same crystal, fig. 5, $m\Omega=71^{\circ}24'$.

P (two faces) on a crystal from Herodsfoot Mine, fig. 11, mP (above) $=55^{\circ}15'$, mP (below) $=55^{\circ}29'$.

S on a crystal from Herodsfoot Mine with *bosyunm*, $mS=53^{\circ}58'$, $my=37^{\circ}20'$, $mu=56^{\circ}40'$.

E on a crystal from Andreasberg between *uy*, with *nae*; it is a broad face, $uE=6^{\circ}1'$, $uy=19^{\circ}29'$.

$K\Gamma$ in a zone containing *myu* and perhaps (12 12 11) on one of a wheel-shaped group of crystals from Herodsfoot Mine, $mu=56^{\circ}37'$, $my=37^{\circ}16'$, $m: 12\ 12\ 11=35^{\circ}0'$, $mK=31^{\circ}11'$, $m\Gamma=25^{\circ}46'$.

Z in a zone containing *gpy* and perhaps (14 14 11) on a crystal from Herodsfoot Mine which has also the face *o* well developed, $oy=32^{\circ}56'$, $yg=16^{\circ}20'$, $y\mu=10^{\circ}6'$, $yZ=7^{\circ}51'$, $y: (14\ 14\ 11)=6^{\circ}17'$, $og=43^{\circ}8'$, $o\mu=38^{\circ}48'$, $oZ=37^{\circ}22'$, $o: (14\ 14\ 11)=36^{\circ}26'$.

D on a crystal from Endellion with *bosuygmvs*; it occurs as a small dull face between *yv* and nearly between *sg*, $yD=12^{\circ}12'$ about.

V as a good bright face between *yp* with $n\Sigma vQ$ and perhaps (18 1 19) on a crystal from Endellion. *V* gives two images, $yV=6^{\circ}11'$ or $5^{\circ}44'$, $y\rho=19^{\circ}16'$, $nV=32^{\circ}57'$ or $38^{\circ}9'$. *Q* is a small face not quite between *V* and *p*. $yQ=10^{\circ}51'$, $nQ=32^{\circ}35'$; and (18 1 19) occurs as a small face beyond *n* in the zone $[pn]$ on the broken edge of the crystal, $n: (18\ 1\ 19)=2^{\circ}19'$, $n\rho=30^{\circ}58'$.

Q (2 faces) on a crystal from Endellion with *cnΣupymfoa*; it occurs as a large bright face between *py*, $yQ=11^{\circ}18'$, $yQ'=11^{\circ}20'$, $cQ=58^{\circ}42'$.

Also (2 faces) on another crystal from Endellion with *nΣupymb*, $yQ=11^{\circ}17'$, $yQ'=11^{\circ}8'$, $nQ=31^{\circ}37'$, $bQ=60^{\circ}18'$, $bQ'=60^{\circ}25'$, and also on other crystals from Endellion.

XTW on two crystal fragments from Kapnik; the specimen has bright bacillary groups of Bournonite dispersed upon Freieslebenite.

One fragment (twinned) is shown in fig. 6, on which $oW=45^{\circ}8'$, $oT=40^{\circ}4'$, $oX=33^{\circ}36'$. The other fragment has the faces $b\odot vW$, $bW=37^{\circ}9'$, $vW=16^{\circ}12'$.

H on a twin crystal from Neudorf, fig. 7, the face gives two images— $cH=52^{\circ}22'$ or $52^{\circ}45'$, $nH=16^{\circ}8'$ or $16^{\circ}34'$.

(097) on a crystal from Herodsfoot Mine as a bright but striated face between *bo*, with *bosu*— $bo=46^{\circ}7'$, $b: 097=38^{\circ}55'$.

(160); on the edge *bb*, of a twin crystal from Servoz is a face between ba_1 , $ba_1=3^{\circ}38'$, $b: (160)\ 9^{\circ}0'$, $bb_1=93^{\circ}35'$.

(18 6 0). A crystal from Neudorf with the forms $abel\theta m_1 no$ contains a twin lamina consisting of y_1 (between two y faces of the first crystal) and a prism face j (18 6 0)? (fig. 8), $yy_1=5^\circ 50'$ (calculated $=5^\circ 50'$), $yj=41^\circ 56'$ (calculated $41^\circ 55'$).

(18 6 0) (16 5 0) on a crystal from the same wheel-shaped group from Herodsfoot Mine which yielded $K\Gamma$ (see above) with $bmfi$, $bm=48^\circ 18'$, $mf=18^\circ 42'$, $m : (18 6 0)=20^\circ 36'$, $mi=26^\circ 29'$, $m : (16 5 0)=28^\circ 29'$.

(720). A crystal from Endellion (twinned) has the forms $n m u o a$ and another prism face, $ma=46^\circ 48'$, $a : (720)=16^\circ 45'$.

(910) on the same crystal mentioned above, as showing two faces of the form $\mathcal{A}$, $a : 910=6^\circ 55'$.

Θ and (17 17 11) on a crystal from Herodsfoot Mine in a zone containing $m\mu y$, $m : (17 17 11)=25^\circ 55'$, $m\mu=26^\circ 28'$, $m\Theta=27^\circ 44'$, $my=86^\circ 55'$; on the same crystal $bo=46^\circ 8'$, $bm=48^\circ 10'$.

(445) on a crystal from Endellion as a curved face, $m : (445)=44^\circ 42'$ to $42^\circ 52'$, $my=37^\circ 28'$.

(1 0 14) on the same crystal with the forms $boxuy \odot \xi nemyp$,
 $n : (1 0 14)=88^\circ 11'$.

(20 20 21) on a crystal from Endellion with $muyox\zeta$, $mu=56^\circ 37'$, $m : (20 20 21)=38^\circ 35'$, $my=37^\circ 25'$, $oy=32^\circ 45'$, $o : (20 20 21)=32^\circ 18'$.

(10 1 9) on a crystal from Neudorf with $cnuym$, and perhaps a face of (18 1 19), $m : (10 1 9)=57^\circ 21'$, $mn=62^\circ 42'$; $u : (18 1 19)=26\frac{1}{2}^\circ$, $un=29^\circ 56'$ about.

(14 14 11) and Z (2 faces) on two juxtaposed crystals from Herodsfoot Mine in the zone my , one crystal gave $my=37^\circ 20'$, $mZ=29^\circ 55'$, $m\mu=27^\circ 10'$, $mg=21^\circ 1'$, $mg'=20^\circ 58'$, $m\mu'=26^\circ 56'$, $mZ'=30^\circ 6'$. The other gave $my=37^\circ 39'$, $m : (14 14 11)=31^\circ 14'$, $m\mu=27^\circ 12'$.

(20 19 88) on a crystal from Herodsfoot Mine with $boxu$, $ux=27^\circ 48'$, $u : (20 19 88)=1^\circ 28'$ (calculated $=1^\circ 2'$).

Indications of the forms (688) (812) (408) have also been observed.

(688) on a crystal from Herodsfoot Mine in the zone ρf , $\rho f=26^\circ 10'$, $\rho : 688=25^\circ 52'$ (calculated $=26^\circ 30'$).

(408) in the zones $[lp]$ and $[an]$ on a crystal from Neudorf.

(812) in the zones $[nm]$ and $[xa]$. Locality doubtful.

Also a rounded face between u and ρ on a crystal from Herodsfoot Mine, to which indices could not be assigned.

As examples of measurements from very good crystals the following are added:—

I. (Cornwall). $bf=61^\circ 50\frac{1}{2}'$, $be=25^\circ 7\frac{1}{2}'$, $b\Phi=75^\circ 16'$, $fp=26^\circ 16'$.

II. (Cornwall). $bm=48^\circ 3\frac{3}{4}'$, $bl=31^\circ 48\frac{1}{2}'$, $bm'=48^\circ 10\frac{1}{2}'$, $bo=46^\circ 17'$.

III. (Cornwall). $ou=28^{\circ}22\frac{1}{2}'$, $bm=48^{\circ}9\frac{1}{2}'$, or $48^{\circ}10\frac{1}{2}'$, bb_1 (twinned) $=93^{\circ}42'$.

IV. (Cornwall). $bo=46^{\circ}9'$, $bs=48^{\circ}46'$, $bu=66^{\circ}28'$, $yp=19^{\circ}24'$, $ys=15^{\circ}0'$, $sz=18^{\circ}41'$.

V. (Cornwall). $oy=82^{\circ}44'$, $om=59^{\circ}39'$, $oy'=92^{\circ}6'$, $ox=18^{\circ}16'$, $ev=25^{\circ}20'$, $bm=42^{\circ}56'$, $fp=26^{\circ}11'$.

VI. (Oberlahr). $cu=88^{\circ}17'$, $am=46^{\circ}51'$, $an=48^{\circ}8'$, $a\Sigma=20^{\circ}24'$, $ay'=57^{\circ}4'$, $cy'=52^{\circ}39'$, $cu'=88^{\circ}14'$, $mn=62^{\circ}49'$.

Of the forms given in the first comparative table, all have been observed during the course of the present study of Bournonite, with the exception of $\tau\beta\psi\chi\zeta\lambda G \Delta$.

Twin-growth.—The subject of Bournonite twins has been so carefully studied by Hessenberg, and so many figures have been given by him and by Schrauf, that the main facts do not require to be re-stated.

The general conclusions drawn from the present examination are—

I. That composition may be either parallel or perpendicular to the twin-plane, but is generally the former.

II. That the twinned crystals are always united by juxtaposition, and not by interpenetration.

The simplest possible case of a twin crystal showing abc as predominating faces will therefore be fig. 4, in which $aa_1=86^{\circ}20'$, $bb_1=98^{\circ}40'$, $mm_1=7^{\circ}20'$.

The corresponding figure with composition perpendicular to the twin-plane is shown in fig. 13, in which

$$aa_1=98^{\circ}40', bb_1=86^{\circ}20', mm_1=0^{\circ}0'.$$

Figure 4 may be taken as the elementary type of Bournonite twinning; the composition is generally repeated with parallel twin planes m , so as to give rise to a number of twin laminæ (compare Hessenberg, fig. 82). The twin structure of crystals from Neudorf, Horhausen, Endellion, and many other localities seems to be generally of a simple character, and to be complicated mainly by the occurrence of twin laminæ.

But the case of the wheel-shaped groups of Herodsfoot Mine and the Rädelerz of Kapnik requires a somewhat more detailed description, because it is left doubtful by Hessenberg, and has been variously explained.

Zirkel regards the Rädelerz as composed of a number of long thin individuals which cross one another like the spokes of a wheel, each one united with some other by the ordinary twin law (twin face m). He also suggests that the structure results from a central cross composed of two

interpenetrating individuals, upon the arms of which are grouped other crystals in twin-position (*cf.* his fig. 89).

Sadebeck (*Angewandte Krystallographie*, p. 120) regards the crystals from Cornwall as interpenetration twins, in which the cruciform structure is not generally apparent because the spaces between the arms are filled up by other individuals twinned upon them. In the crystals from Cornwall and from Siebenbürgen (Transylvania), he says that each cross may be succeeded by another inclined to it at an angle of $8^{\circ}40'$. In this way he suggests that the Rädelerz may be composed of as many as 23 individuals, and 46 rays.

Hessenberg, although he states that he has not observed a genuine interpenetration twin, supposes the Herodsfoot crystals to afford an example of such. The Rädelerz of Kapnik and other complicated groupings he explains as circularly repeated juxtaposed twins bounded by a and b as the predominating faces in the prism zone, and formed by individuals which may have either (1) their brachy-diagonal, or (2) their macro-diagonal axes radiating from the centre of the compound crystal. Compare Hessenberg's figures 27 and 24. He states in consequence, "Wenn man am Goniometer den Winkel von $172^{\circ}40'$ ein-oder aus-springend in der horizontalen Zone auffindet, so dient er als der sicherste Leitfaden, da es die den Zusammensetzungsflächen paarweise nächst benachbarten Flächen m sind, welche zwischen sich mit diesem Werthe geneigt sind."

Quenstedt describes the groups from Cornwall and from Nagyag as interpenetration twins; the Rädelerz of Kapnik and the discs of Cornwall as parallel growths.

The conclusions drawn in the present paper are to some extent at variance with the above explanations, but are based only upon the specimens in this collection.

The suggestions of both Zirkel and Sadebeck start with the idea that the cruciform interpenetration twin is the elementary form, whereas it appears very doubtful whether such a twin of Bournonite has been observed.

The following is perhaps the clearest method of considering complicated twin crystals of Bournonite.

Each successive twinning has the effect of inclining the axes of two individuals at an angle of $8^{\circ}40'$ to one another. It will then be seen that if any number of individuals be ranged beside one another by repeated twinning with inclined twin planes, their axes, and therefore the planes ab , will always be inclined to one another at multiples of $8^{\circ}40'$, and their m planes at multiples of $7^{\circ}20'$. An uneven number of twin repetitions will

bring a of one individual in a neighbouring position to b of another, an even number of repetitions will bring two a or two b faces into neighbouring positions. This will be seen from fig. 14, in which a_1, b_1 is the first position of the axes, m_1 the first twin axis; a_2, b_2 the second position, m_2 the second twin axis, and so on. A measured angle between two a and b faces, or between an a and a b face, will therefore denote at once the number of twin repetitions to which it corresponds.

Thus the angle $b_4, b_4=14^\circ 40'$ ($=4 \times 3^\circ 40'$) of Hessenberg's fig. 26, denotes 4 repetitions; the angle $a_1, b_4=11^\circ 0'$ of his figures 24, 27, and 30 denotes 8 repetitions.

Now in the present examination of the Kapnik Rädelerz, it has generally been found that the angle $7^\circ 20'$ is that between two a or two b faces, and not between two m faces, as stated by Hessenberg; and that the predominating faces are generally m , and not a or b , while the predominating faces upon the edges of a disc of Rädelerz are almost always u , and not o or n , as they are usually represented in figures.

Thus a cruciform crystal of Rädelerz will be represented by fig. 10. But these groups are far more commonly composed of three or more individuals united, as in fig. 9. II. is twinned upon I., III. is twinned upon II., the twin-planes being shown by dotted lines. I. and III. are therefore irregularly united, and $a_1, a_3, 7^\circ 20'$.

Fig. 9 may therefore be added to figures 24, 26, 27, 30, of Hessenberg and figures 15 and 17-21 of Schrauf as a frequently observed mode of combination. The number of individuals, however, varies from 8 to 6 or 7. It may be mentioned that the only safe method of determining the positions of the individuals is by means of the faces *onuy*, &c. From an observation of the prism zone alone it is almost impossible to discriminate between them: $86^\circ 20'$ or $98^\circ 40'$ may be the angle between two m faces of one individual; $7^\circ 20'$ may represent the m faces of a pair of individuals once twinned, or two a or b faces after double twinning; and a, b, m are all smooth bright faces.

The mode of twinning most common in the Bournonite from Liskeard is totally different. The ordinary form of the individuals is that of fig. 11 (without the faces P) or of fig. 8. Two such crystals are usually united as in fig. 12, so that $bb_1 = 86^\circ 20'$, while the two rounded and uneven a faces form a reentrant angle on the inner side of the group. On the outer side the crystals are bounded by the largely extended m faces, as shown in fig. 12, and thin laminæ may generally be traced on these parts of the crystals. The twin-plane is shown by a dotted line. This at first sight appears to be scarcely a case of composition perpendicular to

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the plane of twinning; it might be, in fact, because the crystals do not unite regularly otherwise than *along* the twin plane that the Herodsfoot crystals adopt this form; so that the two individuals do not come into contact at all, but break out directly from the mass of the Bournonite, having the direction of the dotted m plane in common.

To this reluctance, if the term may be used, of two crystals to combine perpendicular to the plane of twinning (where two m planes with a tendency to coincide would be inclined at an angle of $7^{\circ}20'$ *) may perhaps be ascribed the distortion of the crystals, and especially of the a faces near their junction, also the tendency to grouping of other crystals on the outer side of the two principal individuals, as indicated in fig. 12 (b_2), and the oscillatory twinning at the outer corners.

But, on the other hand, in many cases, and especially in the more nearly circular discs, there appears to be no vacant reentrant angle between the two a faces; the crystals come into complete contact, and the two m faces, though uneven, often fall into a plane; so that the Herodsfoot crystals must be regarded as presenting a real example of composition perpendicular to the plane of twinning.

Where there is a reentrant angle between the two a faces, as in fig. 12, it is generally occupied by a small columnar crystal, either parallel to one of the two larger individuals or twinned on one of them, or it may be itself a compound crystal. The crystals which often range themselves in a long series on the outer sides of the two principal members, nearly parallel to them, have abrupt contact along the uneven face a , as shown. The figure also indicates the uneven nature of the face o , and the way in which ξ , v , frequently run out from u across o . A roughly cruciform figure would be produced by the symmetrical repetition of fig. 12 across the dotted line m ; this is the foundation of the cruciform or circular discs from Herodsfoot, the form being complicated by the grouping of other nearly parallel portions of crystals about these individuals.

Finally then it may be concluded that the twinning of Bournonite is by juxtaposition, and not by interpenetration (*cf.* also Schrauf's figures, which mostly point to the same conclusion); that composition perpendicular to the twin-plane is not rare on Cornish crystals; that the Kapnik Rädelerz is complicated more by parallel repetition than by twinning, the number of individuals rarely exceeding 5; and that figs. 9 and 10 are a more truthful representation of the complicated and cruciform crystals

* "It may be noticed that in the case of Aragonite, with which the twin crystals of Bournonite are often compared, this angle is $52^{\circ}20'$."

than those generally given: it may be added that specimens which have repeated twins with inclined planes do not often show signs of twin lamination or repetition with parallel planes.

Irregular Conjunction.—The paper of Vom Rath quoted above deals with the case of four crystals, which have their c faces parallel, but are not twinned; this mode of combination frequently occurs, and complicates the true twins to a large extent; three examples based upon good measurements, and chosen from many observed, are

$$aa_1=81^{\circ}29'; \quad bb_1=82^{\circ}41'; \quad bb_1=88^{\circ}12'.$$

Another irregularity which often introduces a fresh difficulty into the Rädelerz is a tendency to twist, which the crystals show both in the compound groups of Kapnik and those of Herodsfoot, so that the individuals form part of a helix about the vertical axis, and their prism faces do not fall into the same zone.

Zones and Faces.—A few notes may be added on the relative development of the principal zones and their faces.

[*amb*]. a is generally smooth and bright (except from Liskeard); b is very bright, finely striated parallel to the edge bo , and sometimes formed of step-like projections running horizontally; m , bright, striated vertically, as are also most of the prism faces, especially those between ma . Some crystals from Wolfsberg, Kapnik, Mexico, and Liskeard, are columnar, owing to the predominance of this zone.

Some of the crystals from Neudorf, Endellion, &c. have only *amb*, but as a rule those from Endellion show *belma*, while crystals from Herodsfoot Mine are particularly rich in faces between m and a , Φ being characteristic. On some crystals from Neudorf the zone is not represented.

The faces in this zone are sometimes curiously fretted, and have a worm-eaten appearance; this is due to the recurrence on the prism planes of those faces *osyup*, &c. which may be common on the crystals.

[*moun*]. This zone (in which one index is equal to the sum of the other two) is of special importance, owing to the twinning; and the recurrence of twin laminae causes a striation of the faces parallel to their edges.

o is, after b , the brightest and commonest face of Bournonite. It is generally horizontally striated. On Liskeard crystals this face is often either very uneven and dull, or replaced by an uneven concave surface.

u is sometimes bright, sometimes dull; when the u faces of two individuals are brought into conjunction by twinning, one is often bright and the other dull.

n , which is one of the commonest faces on the Neudorf crystals, is

frequently missing on Cornish specimens, owing to twinning, which brings the zone *cob* into prominence; it is smooth and bright.

The part of the zone represented by *WTX* is only to be observed upon specimens from Kapnik in which bright Rädelerz is dispersed upon crystallised Freieslebenite. As is shown in fig. 6, there is no inducement of these faces on an edge, but they run down as a bright tongue towards the prism zone; they are slightly striated parallel to their edges.

[*cob*]. The faces in this zone are generally horizontally striated; *x* is common, and the edges *ox*, *xc*, are often uneven and replaced by uneven faces.

c is for the most part smooth and bright, and in Kapnik Rädelerz, when smooth, scarcely shows any trace of twin demarcations, except a slight striation parallel to the edge *co*; but on some crystals, especially those from Liskeard, *c* is replaced by an uneven rounded surface tending to form itself into faces towards *x* and *o*. Faces between *b* and *o* are rare, the edge *bo* being sharply defined.

[*osyp*]. This zone is especially characteristic of the Liskeard crystals (see fig. 11), in which *s* is sometimes dull, while *y* and *p* are always very bright.

s is generally quite dull, and especially on Neudorf crystals, where it is a large face.

y, always bright, occurs either as a thin face between *um*, or between *yp*, or else with nearly rectangular edges on the edge *on*.

[*ank*]. *N* is usually the only face in this zone between *ao*, and is uniformly smooth; of the others, *κ* is most frequent.

[*uym*]. *uym* are the common faces; the zone sometimes occurs, especially in Cornish crystals, as a series of horizontally striated but bright planes: examples have been given above.

Of other faces *v* (bright) is especially characteristic of Endellion, *v* (dull) of Liskeard crystals.

Finally, a glance at the projection will show a noteworthy fact about the zones. In the zone [*ao*] the intercepts made on the axes by the common faces are exclusively multiples of 8; in the zone [*bc*] the only common faces are *oxtz*, so that the intercepts are generally multiples of 2; in the prism zone, where the common faces are *elθwafιΦd*, they seem to be a combination of both.

EXPLANATION OF PLATES.

PLATE I.

- Fig. 1. Figure of Bournonite from Phillips's Mineralogy.
- Fig. 2. Type of crystals from Endellion.
- Fig. 3. Type of crystals from Liskeard.
- Fig. 4. Twin crystal, combined parallel to twin-plane.
- Fig. 5. A crystal from Endellion.
- Fig. 6. A crystal from Kapnik.
- Fig. 7. A crystal from Neudorf.
- Fig. 8. A crystal from Neudorf.
- Fig. 9. Type of 8-lings from Kapnik.
- Fig. 10. Type of cruciform crystals from Kapnik.

PLATE II.

- Fig. 11. A crystal from Liskeard.
 - Fig. 12. Type of twin crystals from Liskeard.
 - Fig. 18. Twin crystal, combined perpendicular to twin-plane.
 - Fig. 14. Scheme of Axes in repeated twin crystals.
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X. *On the Tetartohedral Development of a Crystal of Tourmaline.*

By R. H. SOLLY, F.G.S., Demonstrator of Mineralogy in the University
of Cambridge.

[Read June 24th, 1884.]

IN working on the isomorphism of Tourmaline I have been struck by the very peculiar development of a fine crystal from Pierrepont, New York, now in the Cambridge Collection.

The crystal is doubly terminated, of a jet-black colour and splendid lustre. It weighs 814.88 grammes, and measures $1\frac{1}{2}$ inch by 1 inch by $\frac{1}{2}$ inch.

The forms present are $r_{\kappa} \{100\}$, $\bar{r}_{\kappa} \{\bar{1}00\}$, $s_{\kappa} \{\bar{1}11\}$, $\bar{s}_{\kappa} \{0\bar{1}\bar{1}\}$, $u_{\kappa} \pi \{8\bar{2}0\}$, $b_{\kappa} \{2\bar{1}\bar{1}\}$, $\bar{b}_{\kappa} \{\bar{2}11\}$, and $a \{10\bar{1}\}$.

Fig. I. is a stereographic projection of the poles of the faces present.

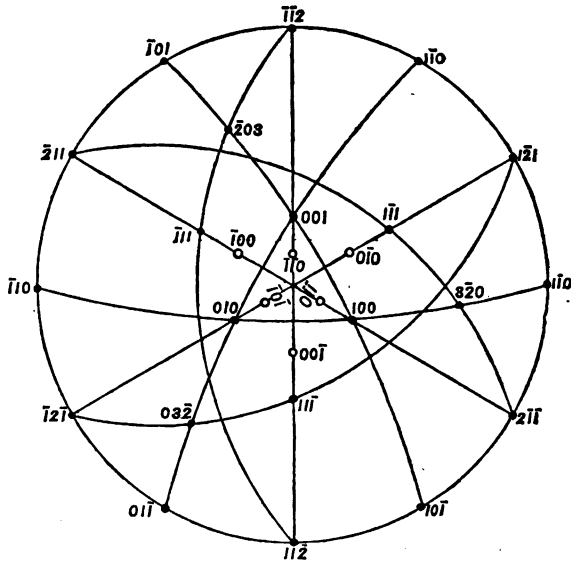


FIG. I.

Figures II. and III. are drawn so as to show in two positions the development of the faces.

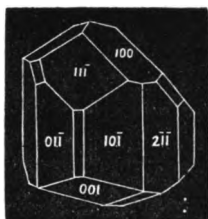


FIG. II.

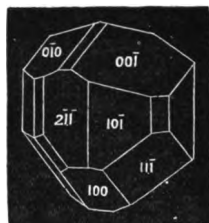


FIG. III.

The form r has all its faces present, but the parallel faces are thrice as large.

The form s is only present with the smaller r faces, and is entirely absent at the other end of the crystal (Fig. II.).

The form e is a narrow plane only present with the large r faces, and is entirely absent at the other end of the crystal (Fig. III.).

The form b has all its faces present, but its parallel faces are unequally developed.

So far the crystal is but a fine example of hemimorphic development, the parallel faces being wanting or very unequally developed.

But u , a scalenohedral form which ought to exhibit holohedrally twelve faces or hemihedrally six faces, appears with only three faces on this crystal, which are all at one extremity of the axis, and arranged in the manner of similar planes on apatite or quartz.

The question then arises: are the three faces which are thus alone found a true tetartohedral development of a scalenohedron; and are we to deduce it from the law of apatite or the law of quartz, since geometrically, on account of the hemimorphic development, it may belong to either?

Though such tetartohedrism is not known to occur on any native mineral, it has been observed on the crystals of an artificial salt.

Groth has described (*Pogg.* 187, 436) crystals of sodium super-iodate (Na I) $\text{O}_4 + 8 \text{ aq.}$ which exhibit tetartohedrism.

But, since these crystals rotate the plane of polarisation, Groth considers them as examples of a hemimorphic development of an asymmetric hemihedral crystal, like quartz.

As crystals of tourmaline do not rotate the plane of polarisation, it is probable that in the case of the present crystal the hemimorphic development is of a semiform, similar to those which have been observed on diopside and apatite, and that the form should be designated crystallographically as $u \kappa \pi \{820\}$.

Though it may be rash to accept a tetartohedral development of tourmaline from the observations of one crystal, still it must be remembered that scalenohedral forms are the only ones which render the observation possible, and that such forms are extremely rare; and, moreover, that the presence of six planes of the scalenohedron at one end of the axis does not necessarily militate against such a view, unless it be shown that these planes are similar in their physical characters.

I have examined several crystals from Pierrepont in different collections; the planes *u* are fairly common in these crystals, but that of the Cambridge collection is the only one in which three planes of the form alone exist; generally it seems as if six planes occurred together at one end of the axis.

Perhaps the observation is sufficiently interesting to justify my calling the attention of crystallographers to it.

The crystal has been measured on a Fuess goniometer with the highest power, and good measurements were obtained, from which the following element was calculated:—

		$ro = 27^{\circ}86\frac{1}{2}$.
	Found.	Calculated.
$s s_1$	$= 77^{\circ}29'$	$77^{\circ}80'$
$r r_1$	$= 47^{\circ}20\frac{1}{2}'$	$47^{\circ}20'$

The pyro-electric property has been tested, and it has been found that while cooling, the end on which the half form *s* appears is the antilogous pole, and the opposite end, on which the half form *e* appears, the analogous pole.

The specific gravity was found to be 8.145.

XI. *Application of the Periodic Law to Mineralogy.*

By THOS. CARNELLEY, D.Sc., Prof. Chemistry, University College, Dundee.

(Communicated by the Rev. W. W. PEYTON.)

[Read June 24th, 1884.]

THE Periodic Law of the Chemical Elements first foreshadowed by Newlands, and subsequently developed by Mendeleeff and Lothar Meyer, states:—(1) *The Properties of the Elements are a Periodic Function of their Atomic Weights.* (2) *The Properties of the Compounds of the Elements are a Periodic Function of the Atomic Weights of their Constituent Elements.* This law was explained and illustrated by several examples in the case of both chemical and physical properties, and attention specially directed to the division of the elements, as arranged in Mendeleeff's table (*Ann. Chem. Pharm.*; Suppl. 1870-72, p. 151) into odd and even series, and to the somewhat peculiar character of the eighth group of that table. These points were further illustrated by a reference to Lothar Meyer's curve of the elements (*Mod. Theor. der Chem.*).

In applying the Periodic Law to Mineralogy, it was pointed out that this could not be rendered so evident as could be wished, since the relationships brought to light by the application of that law in ordinary chemical science referred to chemically pure substances, whereas mineralogy dealt chiefly with bodies whose properties were liable to some variation, owing to their almost always containing more or less of other compounds foreign to their ideal composition, so that any exact relationships which may exist between their composition and general chemical and physical properties are in many cases concealed.

The principal lines indicated in which an application of the Periodic Law to Mineralogy may be of service were as follows:—

(1.) *Reducibility of the Elements to the Free State from their State of Combination.* Elements belonging to odd series are, as a rule, easily reducible to the free state, whilst those belonging to even series are only reducible to the free state with difficulty.

(2.) *Occurrence of the Elements of the Free State in Nature.* This is, of course, closely connected with the property of reducibility already considered, so that we may expect a similar relation to hold good. Elements belonging to even series (except C, N, O, and Group VIII.)

never occur in the free state in Nature, whereas elements belonging to odd series generally and sometimes frequently do occur free.

(8.) *Occurrence of the Elements in the Combined State in Nature.* In reference to what is said under this section, F, Cl, Br and I, and the elements of Group VIII. must be neglected. They are referred to below.

Elements belonging to odd series usually occur in Nature as sulphides or double sulphides (also as selenides, tellurides and arsenides), i.e. in combination with a negative element belonging to an odd series, and only in very few cases as oxides, whereas elements belonging to even series, on the other hand, usually occur as oxides or double oxides (forming silicates, carbonates, sulphates, aluminates, &c.), i.e. in combination with a negative element belonging to an even series, and never (with two exceptions) as sulphides.

Thus:

Elements belonging to even series:—

As oxides, or double oxides	{	<i>Commonly.</i> Li (Lithia mica, &c.), K (nitre, felspar, &c.), Rb, Cs, Be, Ca, Sr, Ba, B, Sc, Y, La, Yb, C, Ti, Zr, Ce, Th, V, Nb, Di, Ta, O, Cr, Tb, W, Mn.
		<i>Frequently.</i> N (in nitre), Mo.
		<i>Rarely or never.</i> None.

The only two of these elements occurring as sulphides are:—

{	<i>Commonly.</i> Mo.
	<i>Very rarely.</i> Mn (also O, as SO ₂ in volcanic gases).

Elements belonging to odd series:—

As sulphides (selenides, tellurides)	{	<i>Commonly.</i> Cu, Ag, Zn, Cd, Hg, Ga, In, Tl, Pb, Sb, S, Se, Te.
		<i>Frequently.</i> As, Bi, Sn.
		<i>Never.</i> Au (occurs only in free state in Nature), Na, Mg, Al, Si, P (for these see Meyer's curve).
As oxides	{	<i>Commonly.</i> Na, Mg, Al, Si, P (for these see Meyer's curve) and Sn.
		<i>Frequently.</i> Zn, Cu.
		<i>Rarely.</i> Pb, Sb, Bi, As.

Group VIII.—The elements of this group, except Fe, Co, and Ni, never occur in Nature in the combined state, and therefore need not be considered in this connection. As regards the first triad of this group—

Fe occurs *mostly* as oxide, but also *frequently* as sulphide.

Co occurs *mostly* as sulphide and arsenide, but *sometimes* as oxide.

Ni occurs *almost always* as sulphide and arsenide, and only *very rarely* as oxide.

Iron, the first member of the triad, thus more nearly resembles elements of the even series; whereas Nickel, the last member, more nearly resembles elements of the odd series. This shows, therefore, in a marked manner that in Group VIII. we have a gradual passage from even series on the one hand to odd series on the other.

The halogens Cl, Br, I and F, being the most electro-negative of the elements, occur in nature in combination with the most electro-positive metals as chlorides, bromides, iodides and fluorides, &c. and are never (if we omit a few metallic oxychlorides and sulphochlorides) found in combination with either oxygen or sulphur.

The only other point necessary to mention is that as regards the odd members of any one group, the tendency to occur in nature as sulphides increases, whereas the tendency to occur as oxides or double oxides diminishes, as the atomic weight increases, thus:—

Group I.	Na*	frequently occurs as double oxide (silicates, Chili salt-petre, &c.), and never as sulphide.
	Cu	occurs commonly both as sulphide (Cu_2S , Cu S , Cu Fe S_2 , &c.), and as oxide or double oxide (Cu_2O , Cu O , malachite, &c.)
	Ag	generally as sulphide and never as oxide.
	Au	only in free state.
Group II.	Mg	always occurs as double oxide (Mg CO_2 , &c.) and never as sulphide.
	Zn	most commonly occurs as sulphide, but sometimes also as oxide.
	Cd	only found as sulphide and never as oxide.
	Hg	only found as sulphide or in metallic state, and never as oxide.
Group IV.	Si	always occurs as oxide or double oxide (silicates).
	Sn	almost always occurs as oxide, but sometimes as sulphide.
	Pb	almost always occurs as sulphide, and only rarely as oxide (minium).

And a similar thing for groups III. V. and VI.

The whole of the above facts may be expressed in terms of Lothar Meyer's curve as follows:—

Elements standing on falling portions of the curve are reducible with difficulty, and never occur in the free state in Nature, or in combina-

* Omitting its occurrence as chloride, since it does not affect the present question.

tion as sulphides, but always in combination with oxygen, forming oxides or double oxides (silicates, sulphates, carbonates, &c.), whereas elements standing on rising portions of the curve are easily reducible and almost always occur (more or less) in the free state in Nature, and also in combination with sulphur and but rarely with oxygen.

4. *The hardness, specific gravity, and fusibility of the elements also vary periodically with the atomic weight, as is best seen by reference to Meyer's Curve.*

5. *The hardness and specific gravity of compounds (occurring as minerals). So far as data will allow of a conclusion we have the following relationships. (a.) Sulphides of the elements of odd series. The specific gravity of the natural sulphides of the elements in any one group increases with the atomic weight, whilst the hardness diminishes. The specific gravity of the sulphides of the elements in any one series diminishes as we pass along the series from the positive to the negative end, whilst the hardness increases up to the middle of the series and then diminishes. (b.) Oxides of the elements of odd and even series. The specific gravity of the oxides of any one group of even or of odd elements (odd not being comparable with even elements) increases with the atomic weight.*

6. *Colour. (a.) As shown by Mr. Ackroyd, many bodies when heated undergo alterations in colour, such that as the temperature rises the colour passes more and more towards the red end of the spectrum, and finally, if the temperature be high enough, to brown and black. (b.) As also shown by Ackroyd, an increase in the quantity of the electro-negative element in a simple binary compound produces a colour change toward the red end of the spectrum.*

(c.) *The influence of atomic weight on the colour of compounds may be stated thus:—Take any series of compounds A_xR_y , B_xR_y , C_xR_y , &c., in which R is any element or group of elements, whilst A, B, C, &c., are elements belonging to the same sub-group of Mendeleeff's Table of the Natural Classification of the Elements. Then as the atomic weight of the elements A, B, C, &c., increases, the more does the colour of the compound pass towards the red end of the spectrum, and then (in many cases) to brown and black.*

In conclusion, a theory was propounded whereby these colour relationships are apparently fully accounted for.

Finally, it should be said that the points mentioned in the paper were brought forward rather as suggestions for future research than as final and definite conclusions.

XII. *On Diatomaceous Deposits in Scotland.*

By W. IVISON MACADAM, F.C.S., F.I.C., Professor of Chemistry,
New Veterinary College, Edinburgh.

[Read June 24th, 1884.]

DEPOSITS of Diatoms have been long known to exist in Scotland, but such deposits have so far always been of limited extent. Specimens for the microscope have been readily obtained from certain localities, such as Peterhead, but the occurrence of large deposits covering great tracts of land was unknown.

In the year 1881 my attention was directed, by Mr. Hamilton Bell, to a white substance he had obtained from the Peat of Aberdeenshire. During April, 1882, I read a short paper before the Edinburgh Geological Society* in which I gave the analysis of a sample received from Mr. Bell, with particulars furnished by the Rev. Geo. Davidson, Minister of Logie Coldstone, Dinnet, who also kindly furnished a list of the Diatomaceæ he had identified in the deposit. The list contains some 200 species.

A further communication on the same subject was made by myself to the same Society at the January Meeting, 1883,† in which I gave the detailed analyses of samples received from the Black Moss, Kinnord, Ordie and Drum, all in Aberdeenshire, and from Gress, Isle of Lewis. A list of species as obtained by Mr. E. W. Burgess from the last named place is included in the paper. To these localities may be added deposits at Aros in Mull, Campbeltown; in Strath Cur, and in Glen Shira, Argyllshire; in Sutherlandshire, &c. &c.

The Black Moss, Aberdeenshire, deposit has been carefully investigated by the Earl of Aberdeen, to whom it partly belongs, and has been found to contain over 800,000 cubic yards, which amount is equivalent to about 150,000 tons weight. Ordie and Kinnord contain at least a like quantity. The deposit at Gress, Lewis, occupies a basin-shaped cavity, not many feet above sea-level, and is said to be more than 12 feet deep.

The Glen Shira deposit has not been as yet worked sufficiently to prove its extent, but from scattered notices (principally by Professor Gregory, of Edinburgh) I am inclined to consider it one of our largest deposits, and I intend to spend some time on the ground during August and September this year.

* *Transactions Geological Soc of Edin.* Vol. IV. Part 3.

† *Trans. Geol. Soc. of Edin.* Vol. IV. Part 3, p. 277.

The material is sometimes obtained from Morasses or Lochs, but is more generally found forming a bottom layer or stratum underlying peat. This lower layer has long been known, and wherever peats have been cast in the Highlands the cutting is suspended when the "white layer" is reached. G. H. Kinahan also refers to this lower layer,* but does not mention of what it is composed.

When freshly cut the substance is brown in colour and very similar to the overlying peat, but when dried acquires a light gray colour. The material forms a light porous mass of Diatoms bound together by fragments of *Sphagnum*, *Equisetum limosum* and *E. fluviatile*, *Phragmites communis*, &c. &c.

I have made a careful series of analyses of the various deposits, and the results will be found in the tables at the end of the present paper. The proportion of siliceous matter (Diatoms with a few particles of sand) varies from 50 to 95 per cent., the remainder consisting of organic matter (woody fibre, &c.). The proportion of sand is very small, and in this respect the deposits compare favourably with the Kieselguhr obtained from the Continent. The Aberdeenshire specimens are also very free from iron, and yield on calcination a mass which has an absorbent power in excess of Kieselguhr in the following proportions:—

Kieselguhr (Lauenburg)	816
Sutherland Diatomite	881
Aberdeenshire ,, ...	639

or taking Kieselguhr at 1, the Sutherland deposit will be equal to 1·2, and the Aberdeenshire beds to 2·02.

This absorbent power is being largely taken advantage of in this country by Messrs. Nobel's Dynamite Company, who have to a great extent employed this substance in place of Kieselguhr, and with good results. Other uses, such as the artificial manufacture of Ultramarine, suggest themselves.

ANALYSES OF DIATOMITE.

	No. 1. Margin.	<i>Black Moss.</i>	No. 3.	<i>Ordie Moss.</i>	
		No. 2. Centre.		No. 1.	No. 2.
Organic Matter	43·472	38·613	28·286	50·570	38·586
Inorganic Matter	56·528	68·387	71·714	49·480	66·414
	<i>Drum Moss.</i>	<i>Kinnord.</i>	<i>Lewes.</i>	<i>Sutherland.</i>	
Organic Matter	4·779	22·871	13·874	18·08	
Inorganic Matter	95·221	77·629	86·125	86·92	

* *Geol. of Ireland*, Cap. 16, and *Journal of Science*, No. XLIII. July 1874.

DETAILED ANALYSES OF THE INORGANIC CONSTITUENTS OF DIATOMITE.

	No. 1. <i>Margin.</i>	<i>Black Moss.</i> No. 2. <i>Centre.</i>	No. 3.	<i>Ordie Moss.</i> No. 1.	No. 2.	<i>Drum Moss.</i>	<i>Kinnord Moss.</i>
I. Soluble in Water.							
Calcic Oxide	0.741	0.946	0.841	0.765	0.862	0.943	1.040
Magnesian "	0.982	0.552	0.548	0.482	0.871	0.456	0.606
Potassic "	0.076	0.219	0.224	0.187	0.108	0.815	0.827
Sodic "	0.048	0.874	0.289	0.253	0.242	0.882	0.788
Sulphuric Anhydride	0.168	trace.	trace.	trace.	trace.	0.171	trace.
Chlorine	...	...	...	...	...	...	...
II. Soluble in Acid.							
Ferric Oxide	1.908	1.848	2.885	6.565	2.273	1.459	4.120
Aluminic "	0.286	0.429	0.407	0.201	0.154	1.104	1.854
Calcic "	2.797	2.692	2.484	2.897	0.782	2.878	0.998
Magnesian "	0.670	0.741	0.646	0.632	0.826	0.854	0.205
Alkalies	0.268	0.187	0.215	0.194	0.103	0.358	0.143
Phosphoric Anhydride	...	...	...	...	...	...	...
Soluble Silica	0.541	0.621	0.487	0.441	0.281	1.121	0.921
III. Silicates decomposed by Hydric Fluoride.							
Ferric Oxide	0.142	0.089	0.156	0.166	0.579	4.853	0.142
Aluminic "	0.585	0.202	0.842	0.888	0.468	4.404	0.803
Calcic "	0.114	0.132	0.127	0.155	0.432	2.186	0.058
Magnesian "	0.022	0.071	0.095	0.102	0.188	0.682	0.014
Silica (mostly Diatoms)	91.067	91.012	87.962	86.125	93.075	77.498	88.282
	99.600	99.704	99.658	99.548	99.689	99.514	99.696

XIII. *On the Age and Origin of the Metallic Veins of the Upper Harz.**

By H. M. CADELL, B.Sc., H.M. Geological Survey of Scotland.

(Communicated by the Rev. W. W. PEYTON.)

[Read June 24th, 1884.]

CONTENTS.—1. Topography; 2. Geology of the Harz Mountains; 3. Faults of the Upper Harz; 4. The Clausthal Veins; 5. St. Andreasberg Veins; 6 Suggested Origin of Veins.

1. The Harz Mountains rise from the great plain of secondary and tertiary formations in the western part of Prussia, about 180 miles inland from the seaboard at the mouth of the Elbe. Like the Thüringer Wald and other adjoining ranges, the Harz trends in an approximately east-south-east and west-north-west direction, and resembles on the map an elongated ellipse with a northern flattened side some 50 miles in length. It has been compared to a single mountain with large shoulders, culminating in the celebrated Brocken, 8,746 ft. in height. A line drawn through the Brocken from north to south roughly divides the region into two parts. The eastern division, drained by the Elbe, is rather flat and featureless. It has an average height of 1,600 ft., and is locally known as the Lower Harz (Unterharz). The Western or Upper Harz (Oberharz), drained by the tributaries of the Weser, rises to a height of about 2,000 ft., and is the seat of the great lead and copper mines for which the Harz Mountains have been for many centuries renowned.

2. The Lower Harz consists principally of graywackes, clay-slates and shales with Devonian fossils and some graptolites. The series has been named from the Harz *Hercynian*, and corresponds to Barrande's *Etages* F, G, H, which occupy a position intermediate between the Silurian and Devonian systems of the Bohemian basin. Patches of Devonian rocks occur at several parts of the Lower Harz associated with intrusive and interbedded diabases and tuff-beds.

The Upper Harz contains, in addition to Devonian sandstones, shales and limestones, a large area of graywacke and shale, which extends over

* An extended description of the geology of the Harz Mountains, with illustrations, map and sections, and with a list of the most important German papers on the subject, is given by the author in the *Proc. Roy. Phys. Soc. Edin.*, Vol. VIII., 1883-4, pp. 207-266.

the western and southern parts of the district, and was found by Murchison to be of Culm or Lower Carboniferous age. The Hercynian rocks are developed only in the south-western corner of the Upper Harz between Herzberg and St. Andreasberg.

The huge granite boss of the Brocken, believed by the old disciples of Werner to form the foundation of the "transition series," is one of the newest rock masses of the Harz. It rises as a great stock-like mass through the palæozoic formations, sending out apophyses or offshoots into the surrounding strata, which have been highly altered by the contact metamorphism produced in its vicinity.

Many dykes and bosses of basalt, diabase, kersantite, quartz- and orthoclase-porphry, gabbro, syenite and enstatite rock traverse the palæozoic series, some of which are younger, but the majority either contemporaneous with, or older than, the granitic masses.

The palæozoic core of the Harz passes on its eastern, southern, and western sides underneath the slightly undulating formations of the plain. The old rocks are generally highly contorted, and strike as a rule north-east and south-west. The newer formations, beginning with the Upper Coal Measures and Red Permians, appear along the flanks of the Harz and rest in violent unconformability on the older strata. There must therefore have been a great upheaval and denudation between the time of the Culm and that of the Upper Coal Measures. The latter are generally overlapped by the red sandstones, shales and porphyrites of the Rothliegendes or Lower Permian group. These are in turn overlapped by the limestones and gypsum beds of the Zechstein or Upper Permian series which, along the western flanks of the Harz, creeps up over the Culm graywackes and completely conceals the underlying beds of the Rothliegendes.

The Harz is bounded on the north by a huge fault which runs for a distance of over 40 miles along the base of the mountains, and abruptly truncates the palæozoic rocks of the core. The edges of the secondary rocks are bent upwards and actually inverted along the line of fault, so that they appear to dip inwards below the mountains. The lowest beds are concealed, and no basal unconformability is to be seen on the downthrow side. It is only at Ballenstedt, near the eastern end of the fault, that the unconformability on the upthrow side has escaped removal by denudation. The Coal Measures and Red Permian sandstones are there found resting in a thin cake on the edges of the core rocks, in the same way that the Old Red Sandstone rests unconformably on the Highland schists on the north side of the great Caledonian fault between Crieff and Cortachy in Forfarshire.

Conglomerates containing pebbles of Harz rocks occur in the Coal Measure and Permian beds at Ilfeld on the southern side of the range. The highest of these conglomerates forms the basement of the Zechstein group, but from this horizon upwards to the tertiary deposits no trace of palæozoic detritus is to be found in any of the secondary strata. The ancient Harz must have begun to sink during the Permian period, and become completely submerged ere the Zechstein was all laid down. The emergence did not begin till the Cretaceous period, when signs of earth movement began to appear. The whole country was laid bare after the deposition of the Senonian or Upper Cretaceous group, and has since remained exposed to sub-aërial denudation, which has entirely removed the mesozoic covering as well as much of the palæozoic core below. The great brown coal deposits of Germany were formed in hollows or lakes during the Oligocene period, and one of these occurs in the neighbourhood of Thale and Blankenburg near the eastern end of the great fault. The brown coal here lies in a hollow, one end of which is clearly within the palæozoic area, and the other on the top of the Zechstein, which is here very thin and tilted up on end against the face of the fault. The fact of the deposit thus crossing or at least lying on the top of the line of dislocation, proves that the relative motion had entirely ceased previous to the Oligocene period.

8. The Upper Harz is traversed by a series of great faults which run through the highest Culm beds and also through the granite which pierces them. The faults must thus have been formed after the irruption of the granite. They run outwards to the edge of the range, and pass below the Zechstein, which abruptly cuts them off along with the quartz porphyry dykes which have sometimes risen along the lines of fissure. The faults are thus of Upper Carboniferous age, as they have evidently been formed between the time of the Culm and that of the Rothliegendes, when the porphyries were injected. They were certainly formed long before the Upper Permian period, as the Zechstein beds were laid down after the rock masses on each side of the faults had ceased to move, and had been planed off to an equal level by sub-aërial denudation. The series of faults runs from west to east past Clausthal towards Altenau. Similar faults cross the Bruchberg, a high spur of the Brocken between Clausthal and St. Andreasberg, and run into the St. Andreasberg mining district about 10 miles south-east of Clausthal, truncating or traversing the south-western end of the granite at that locality. The main faults at St. Andreasberg are generally parallel to those at Clausthal, and the two systems of dislocation are with good reason supposed to be contemporaneous in origin, although no faults have been actually traced the whole

distance from one locality to the other. If the faults which run westwards from Clausthal and pass under the Zechstein be thus contemporaneous with the Andreasberg faults farther east, the age of the granite is at once accurately determined. It must have been injected during the Upper Carboniferous period. The great metallic veins of the Upper Harz are in the fissures produced by these faults. The veins of the Clausthal plateau are either in the graywackes and "posidonomya shales" of the Culm, or else between Culm and Devonian rocks which, to the north of Clausthal, are brought together by a fault with a downthrow of over 100 fathoms.

4. The Clausthal veins are mined for lead, copper, and zinc, and are all very similar in mineralogical character. Dr. A. von Groddeck, Professor of Mineralogy and Geology, and Director of the Royal Mining Academy at Clausthal, is the author of one of the best existing works on Ore Deposits.* He has adopted the plan of classifying them according to certain types usually named after a locality where they are most strikingly developed. Veins similar in geological and mineralogical character to those of the Upper Harz are thus brought together under what he has named "Type Clausthal." This type is characterised by "Veins in stratified rocks of various ages, containing argentiferous galena, zincblende, copper and iron pyrites, with quartz, calcspar and chalybite in all proportions, barytes and other minerals occurring subordinately."

The Clausthal veins are large, sometimes reaching a thickness of over 180 ft. The footwall is sharply defined, but the hanging wall is usually shattered and rough, and passes into a fault-breccia containing fragments of graywacke and shale. It is a curious fact that calcspar is only found in the area north-east of the Innerste Valley and northwards from Clausthal, while barytes is confined to the portions of the veins traversing the western and south-western parts of the Upper Harz plateau. The ore is distributed in diagonal bands (*Erzfälle*) which slope towards the west, but occasionally occurs in vertical ribs (*Erzsäulen*) coinciding with the direction of hade, usually to the south. The same diagonal system of distribution obtains in the galena vein formerly mined at Tyndrum in Perthshire.†

The Clausthal mines are worked by the Prussian Government, and have now reached a depth in some shafts of 400 fathoms. There is a magnificent series of dressing works, to which the ore from the various mines is

* "Die Lehre von den Lagerstätten der Erze." Leipzig, Veit und Co. 1879.

† See description of the Tyndrum mines, by J. S. Grant Wilson, and H. M. CADELL, in *Proc. Roy. Phys. Soc. Edin.*, 1883-4, p. 195.

brought. A great subterranean canal, communicating with a main drawing shaft at the dressing floors, connects the underground workings, and serves both as a mode of transit for the ore and as an adit level to drain the mines in the Clausthal district. The most improved systems of mining and dressing the ores are adopted, and new apparatus is from time to time introduced. At Clausthal there is a Royal Mining Academy, where students are well trained in the theoretical as well as the practical branches of metal mining, and have altogether exceptional opportunities for visiting the numerous mines, dressing floors, and smelting works, on and around the Harz, to which they have at all times free access. Coal does not occur on the Harz in workable quantity, and water is largely used as a motive power. The whole plateau of the Upper Harz is dotted over with artificial ponds and reservoirs, many of which are picturesquely situated in sequestered spots among the fragrant pine forests with which the whole region is densely clothed. The water is brought in neatly cut channels from the ponds to the wheels and dressing floors at the mines. Many of the waterways are very long, one of them which comes from a shoulder of the Brocken reaching a length of some 16 miles. They wind pleasantly about among the forest glades, sometimes crossing a valley on the top of a high embankment, and at others plunging into a shaggy mountain side to reappear and resume the even tenor of their way in the valley beyond.

5. The celebrated silver veins of St. Andreasberg are all situated within an area resembling a very obtuse isosceles triangle whose base is about 4 miles in length. Two sides of the triangle are barren fault fissures (*faule Ruscheln*) full of soft fault-rock, made up chiefly of fragments of clay, slate and shale. These have a southerly hade and a breadth sometimes reaching 200 ft. The silver veins are thin, seldom exceeding half a yard in thickness. None of them pass out of the area just described: all out-siders are base, containing only copper pyrites and ironstone. The argentiferous veins run roughly in two directions: the first set, containing several veins, has an average strike of E 60° S and a steep hade to north-east, while the two veins of the second system run approximately E 15° S and hade to north at an inclination of 60° to 85°. In the network of veins thus formed are found the many rare and valuable minerals for which Andreasberg has so long been famous. The silver veins are filled chiefly with turbid white calcespar, which encloses grains, strings, and nests of quartz, and occasionally fluor, while splendid drusy cavities with crystallised calcite, apophyllite, and other zeolites, are often disclosed. The chief metallic minerals are galena, zinc-blende, native arsenic, ruby silver (pyrargyrite), antimony silver, arsenic silver, silver glance, smaltine, Breit-

hauptite and kupfernickel. The cobalt and nickel ores occur only in subordinate quantities. It has always been found that the silver veins become barren where they have a great thickness.

The Andreasberg veins are thus essentially different in mineralogical character as well as in dimensions from the great lead and copper veins of Clausthal. They resemble the veins of Przibram in Bohemia, and are cited by von Groddeck as examples of his "type Brand," named from a district near Freiberg where great numbers of such veins occur.

6. The origin of metallic veins has been explained by four theories—the *Congeneration theory*; the *Lateral Secretion theory*; the *Descension theory*; and the *Ascension theory*. Each is no doubt true in particular cases, but as a general rule the last three are alone applicable to the great majority of mineral veins. Of these the descension theory has perhaps the least support, but on considering the circumstances connected with the formation of the majority of the veins of the Upper Harz, it appears to me that perhaps this hypothesis is worthy of more attention than it usually receives.

The Harz formed part of a terrestrial area during the Upper Carboniferous and Lower Permian periods, as we have seen. The upturned and contorted Devonian and Lower Carboniferous strata were faulted and subjected to sub-aerial denudation, which went on till the beginning of the Zechstein or Upper Permian period, when the whole region became completely submerged. The highest of the conglomerates derived from the erosion of the ancient Harz occurs at the base of the Zechstein series. It is overlaid by the celebrated seam of Kupferschiefer or copper shale, extensively mined in the Mansfeld district at the south-eastern extremity of the range. The Kupferschiefer is only about 18 inches in thickness, but extends over a very large area, as it is found cropping out along the whole southern border of the Harz, and also on the flanks of the Thüringerwald, in Saxony. It is simply a bituminous shale containing small quantities of metallic sulphides in the form of very fine particles or powder. The chief minerals are copper and iron pyrites, erubescite, copper glance, silver glance, zinc-blende, galena, kupfer-nickel, and smaltine. Although the shale contains not more than 2 to 3 per cent. copper, and 0.01 to 0.20 per cent. silver, and the workable part of the seam is less than a foot in thickness, it is very uniform in quality over large areas, and the great difficulty and expense incurred in sinking deep shafts through watery strata is amply repaid by the value of the silver and copper extracted. The area in which the shale was deposited must have contained large quantities of metallic matter in suspension or solution. It was inhabited by an abundant fish fauna, represented by the species *Palaeoniscus Freieslebeni*,

and *Platysomus gibbosus*; many beautiful specimens of which are from time to time exhumed by the miners. The fine mud being deposited uniformly over the sea bottom, was mixed with particles of decomposing organic matter, which reduced and precipitated as sulphides some of the suspended metallic ingredients in the water.

The metals in the shale were no doubt derived from the denudation of rocks containing small quantities of metallic matter, in the form of silicates, oxides, or sulphides. Felspars have been found to contain small quantities of metallic matter, and as nearly all crystalline rocks contain much felspar, their decomposition would set free the metallic constituents. These would be carried off in solution if the water contained a sufficient quantity of solvents to prevent their immediate precipitation. Sulphides also occur abundantly, particularly in the palaeozoic formations, and the Harz contains one very remarkable contemporaneous deposit of this character in the celebrated pyrites bed of the Rammelsberg, near Goslar. The ore deposit of the Rammelsberg is interbedded with upper Devonian shales, and has been disclosed to a longitudinal distance of 1,400 yards, a thickness sometimes reaching over 60 feet, and an extent along the direction of dip of nearly 1,000 feet. It consists of laminæ of copper, iron, and arsenical pyrites, with argentiferous galena, zinc-blende, fahlerz, and other minerals regularly interbedded, and partaking of the crumplings and folds of the surrounding rock. For aught that can be proved to the contrary, there may have been similar deposits in parts of the Harz and other districts, removed by denudation during the Permian period, which may have added considerably to the proportion of metallic matter in the Kupferschiefer lake.

When the Kupferschiefer was being deposited over the floor of the basin, the newly submerged faulted area must have been covered by the Zechstein sea, and the metalliferous fluids would have free access to the fissures below. The metallic ingredients in the shale probably represent only a small percentage of the total quantity originally suspended or dissolved in the water, and their precipitation was no doubt regulated by the quantity of organic matter set free. The deposit has evidently accumulated very slowly, and the fissures may have remained open to the metalliferous fluids for a very long period before a change of conditions stopped its further deposition, and the basin became part of a great salt sea on whose floor the overlying limestones and anhydrite beds were precipitated.

I am well aware of the many difficulties with which the hypothesis I have thus roughly sketched out is beset. I have ventured to bring it

forward merely by way of suggestion, as it seems to me there is much room for investigation into the origin of metallic deposits, from the point of view of the geologist as well as from that of the mineralogist and chemist. Too much faith is sometimes placed in the operation of imperfectly understood subterranean agencies, and this is an example of a possible explanation of perplexing phenomena by an appeal to known agencies which have acted at the surface, and can there be investigated with tolerable security and ease. I am quite prepared to see the theory very much modified, or even altogether rejected, but I think that sub-aërial agencies may have had more influence on the formation of metallic veins than is usually supposed, and that the Descension theory deserves more respect than it generally receives.

XIV. *The Origin of the Andalusite-Schists of Aberdeenshire.*

By JOHN HORNE, F.R.S.E., and Geological Survey of Scotland.*

[Read June 24, 1884.]

PERHAPS the most difficult question in the science of Geology at present, is the explanation of the origin of the metamorphic crystalline rocks which occupy large areas on the surface of the globe. These rocks have been generally regarded as having undergone a vast amount of change in lithological character, to which the term metamorphism has been applied. By local or contact metamorphism is meant the transformation which has been effected in ordinary sedimentary strata by the intrusion of igneous rocks, the extent of which depends on the relative size of the intrusive mass. Where a thin sheet of dolerite has been injected amongst Carboniferous strata, which is of common occurrence in the Scotch coalfields, the coal seam is frequently converted into anthracite. Where a large mass of granite has been intruded among Silurian rocks, as is the case in the south of Scotland, then the local metamorphism occurs on a larger scale. In the belt of strata encircling the granite masses in Galloway it is possible to trace the gradual passage of the greywackes, flagstones and shales, into quartzites, argillites and mica-schists, while the fossiliferous black shales become so altered within two miles of the granite that all traces of the graptolites are destroyed. The origin of this local metamorphism is therefore surrounded with little difficulty. It is different, however, with regional metamorphism. This term, which was first used by Daubrée, is intended to refer to those wide tracts of country which are wholly or mainly occupied by stratified crystalline rocks, such as gneiss, mica-schists, and quartzites. Various theories have been advanced in order to account for the origin of these crystalline rocks. By many geologists they are believed to be the altered representatives of ordinary sedimentary deposits, the nature and extent of the change being determined in a great measure by the chemical composition of the original sediment. This theory has been advocated by Bischof, Rose, Haidinger, Dana, and Sorby. An explanation has also been advanced which ascribes many of the metamorphic rocks to chemical precipitation.

* Published with the permission of the Director-General of the Geological Surveys.

The advocates of this theory maintain that the chemical ingredients necessary to form the various kinds of schist were held in solution and precipitated as sediments on the sea floor. The minerals now found in these schists crystallised during this sedimentation, and cannot be regarded as of subsequent origin. One of the ablest advocates of this theory is Dr. Sterry Hunt, and it has been supported with certain modifications by Gumbel, Delesse, and Scheerer.

The object of this brief communication is to show that the phenomena presented by the clay-slates and andalusite-schists of Aberdeenshire are quite at variance with the latter hypothesis. The clay-slate series, which is admirably displayed on the coast-line between Macduff and Gamrie, consists of well-bedded flags and shales, with occasional bands of quartzose grit and fine conglomerate. These beds cover a belt of country from eight to ten miles broad, stretching south-westwards from the sea-coast by the Culsalmond, Foudland and Kirkney Hills to the high grounds of Aberdeenshire. Over a large part of this tract the strata are nearly as unaltered as many of the Silurian rocks of the south of Scotland; indeed no one who is familiar with the appearances presented by sedimentary rocks could possibly doubt the sedimentary origin of the clay-slate series. Cleavage is more or less developed in many of the flags and shales, and in certain areas they are true slates.

On both sides of this belt of argillaceous strata there are zones of andalusite-schist, which stretch far into the country from the coast. At various points along the boundary lines between the clay-slates and the andalusite-schists it is possible to trace an intermediate zone of knotted schists, which are analogous to the rocks termed *Knotenschiefer* by the Germans. The detailed microscopic description of these different types of rock will be published at a subsequent date; but from a careful examination of a number of microscopic sections, it is clear that there is a gradual passage from the one to the other. In the rudimentary stage a rude foliation is developed, the quartz and mica being arranged in lines more or less distinct. The ordinary clay-slate merges at this stage into a slaty mica-schist. To this succeeds more perfect foliation, with the development of extremely minute ovoid knots or concretions, which under the microscope present few appreciable differences from the surrounding matrix. From the microscopic evidence it seems clear that they are formed by the segregation of portion of the matrix. Sometimes the knots are surrounded with a well-marked border or periphery, while again in other examples no border is visible. In the more advanced stages of alteration the matrix becomes more coarsely crystalline, the wavy outline of the mica-schist



being very apparent. There are two varieties of mica present, a brown, and a pale greenish coloured variety; the former of which exhibits marked dichroism. These are arranged in close bands with intervening quartz grains. The nodular segregations present certain differences from the surrounding matrix. They consist of an extremely fine-grained substance which has little action on polarised light, with some recognisable grains of quartz and mica. Along with these are abundant minute specks of a black substance resembling magnetite, which is also distributed throughout the rock. In the last stage of alteration the perfect rhombic prism of andalusite is observable in the soft mica-schist. Frequently the perfect prisms are associated with the knots in the same specimen, while in others the schist is studded all over with regular prisms. These *knotenschiefer* occupy extensive areas in the county, and present features of great interest. The gradual passage from the clay slates, which are truly sedimentary deposits, through the *knotenschiefer* into the andalusite-schists, seems to me to be quite at variance with the hypothesis of chemical precipitation advocated by Dr. Sterry Hunt; while it is satisfactorily explained by the theory of regional metamorphism established by Bischof.

XV. *The Mineral Albertite, Strathpeffer, Ross-shire.*

By W. MORRISON, M.A., &c.

(Communicated by the Rev. W. W. PEYTON.)

[Read June 24th, 1884.]

Chemical Composition.—This body is a hydrocarbon which has been classed under the Asphalt group; but, unlike Asphalt, it does not melt at 100° C., nor is it at all soluble to the extent Asphalt is in such solvents as ether, oil of turpentine, benzol or carbon disulphide. When heated in a closed tube it shows incipient melting after intumescing, but, at the same time, it decomposes into its constituent gases. This chemical change takes place at 800° C. In the above solvents about 5 per cent. of bitumen is obtained. Carbon disulphide softens the mass throughout to a pasty consistence.

In 100 parts of Albertite there are of—

Volatile matter	...	...	...	62.00
Fixed Carbon	...	...	...	37.00
Water	...	...	...	.60
Ash, Sulphur ...	...	...	...	A trace.

Detailed analysis by Prof. Penny, C=79.75, H=8.12, N=1.63, O=10.80, Ash=.20.

The chemical composition given by Boussingault for the black insoluble residue of Asphalt is C=75.5, H=9.9, O=14.8—giving the formula $C^7H^{11}O$, and answers so far to the foregoing analysis by Penny, which I obtained from Sir James Mackenzie, Bart., of Findon, for whom the analysis was made. Albertite does not, however, behave like Asphaltene when treated with oil of turpentine. It does not easily dissolve, like Asphaltene, in oil of turpentine, or in naphtha, nor does it easily melt without decomposition at 800° C.

Physical Properties.—It becomes negatively electric by friction like amber and jet. It differs from jet by its superior lustre and conchoidal fracture. This lustre it loses after some use. It has been made into ornaments like jet, but its lack-lustre and brittleness are defects. It is much more porous than jet. Under the microscope it shows fine lamination on edge. The streak is black, not blackish-brown as in Asphalt.

The specific gravity of Albertite is 1·089, that of Asphalt is from 1·00 to 1·60. Altogether on chemical and physical grounds it must be ranked as a distinct genus of the hydrocarbon or mineral resins, intermediate between the coals and the asphalts. I consider it to be an oxidation product of petroleum.

Geological Position.—In the Strathpeffer district, Albertite is found in veins, of thicknesses varying from the thinness of writing paper to two and three inches thick. The veins in all cases are vertical or nearly so, and run horizontally east and west—strange to say in one invariable direction, no matter what the geological formation may be in which they are found, whether that be gneiss, micaceous sandstone, or conglomerate.

Attention, it seems, was directed to the existence of this mineral in 1825, by Witham (who visited Strathpeffer the previous year), in a paper read before the Wernerian Society of Edinburgh. According to Jameson's description of Asphalt, Witham classed Albertite as Asphalt, and specifically termed the Strathpeffer variety a "slaggy mineral pitch." Witham expressed astonishment at finding such a mineral in "primitive rock." The same mineral, according to Dawson (known as "Albertite" since his description of the variety found in Albert County, New Brunswick), is found at the base of the Carboniferous formation.

Between the gneiss, or metamorphosed Silurian of Murchison and Geikie, in which this mineral is found at the head of Strathpeffer Valley, and the compact micaceous and calcareous sandstone, in which it again appears farther down the valley, is that deposit of the bituminous shales which supply the famed Spa Wells of Strathpeffer with their characteristic constituents of sulphuretted hydrogen, and salts of magnesia, lime, &c. These shales are strongly impregnated with bituminous matter in the neighbourhood of the Albertite veins, and are thus suggestive of having a common origin with the mineral in question. Whether the bituminoid matter be the source of the mineral, or both are from a common origin, the fact of the presence of the mineral in the gneiss underlying these shales leaves open to question.

No Albertite veins are seen in the shales proper, and, where found, no bituminoid matter saturates the rock in which these veins are seen. The cracks in the Conglomerate of the Old Red, which in this district overlies the micaceous sandstone and the shales, and not underlying these, as commonly believed—are cut as clean, and sheer down through the mixed mass as if made by some gigantic knife. Those cracks only which run east and west contain the Albertite, quite as pure and as compact as in the

underlying sandstone. In cracks running in other directions no Albertite is found.

I am disposed to think that the shales interjacent between the underlying gneiss and the overlying sandstone and still higher conglomerate received their bituminoid matter from the same hypogene source, whatever that may have been. Doubtless superheated steam and air played a principal part in the process. The hydrogen, nitrogen, and oxygen of the substance are easily accounted for by this hypothesis, but whence the carbon?

XVI. *On the Occurrence of Prehnite and other Minerals in the Rocks of Samson's Ribs and Salisbury Crags.*

By ANDREW TAYLOR, F.C.S., A.G.S.E.

(Communicated by the Rev. W. W. PEYTON.)

[Read June 24th, 1884.]

WITH little else than the trouble of surveying one of the finest of Edinburgh landscapes, the tourist beginning work amongst the *débris* just to the south of where Samson's ribs overhang the road, and continuing on the road along Salisbury Crags to Holyrood Palace, will meet with a continuous display of the relations specially of zeolitic minerals, and their containing rocks. If he care to pursue the literature of the subject, Daubrée's investigations on the genesis of zeolites, as well as Allport's, Bonney's, and Geikie's petrological researches into the microscopy of the rocks in question, will suggest even more lengthened studies.

Good hand specimens of prehnite are easily obtained amongst the *débris* just mentioned, as well as in the two wall-veins betwixt the columnar pillars above it. Pectolite may also be got here. Large specimens in drusy cavities, such as adorn the magnificent suite of local minerals in the Edinburgh Museum of Science and Art, are only got at rare intervals, when rocks are being blasted for road making and the like. Thus the late Mr. Alex. Rose obtained such a specimen just above Samson's ribs when the Queen's Drive was being cut. The same local mineralogist obtained an equally handsome drusy cavity, filled with prehnite, analcime, and their allies, at the piercing of the Calton Hill Tunnel for the North British Railway. Specimens of the large analcimes, rather plentiful in 1818, when the dolerite quarries along the Radical Road were being worked into Salisbury Crags, adorn the Edinburgh Museum; but Mr. Thomas Allan carefully noted how these were got only when the quarrymen reached the centre of the dolerite bed: as if to anticipate the modern chemical hypotheses of the formation of these minerals, he noted the large proportion of calcareous matter both at the junctions of this bed with the sedimentary strata, as well as in the vents along its course.

Leaving Samson's ribs for the Radical Road, which skirts along Salisbury Crags to near the entrance of the Park at Holyrood, we may glance

in passing at the section of sedimentary strata in a hollow of the Queen's Drive just below the Echoing Rock. For these dolomites, cherty sandstones, and ferruginous clays, will be companions of our walk. They appear here to be cut off by the intrusion of Arthur's Seat itself; and the metamorphoses they undergo are classic representations of the unity of mineralogy and physical geology. The large deserted quarry at the eastern end of Salisbury Crags, containing Hutton's Pulpit with its up-turned vein of hæmatite and calcite, demands a careful scrutiny. Just at its entrance, on climbing up the old spoil-bed, may be seen a white projection through the dolerite which I have elsewhere described as the South vent.* The rock here gives traces of cupric oxide. Towards the back of Hutton's Pulpit, white bounding veins of calcite and other matters cover exposed portions of the greenstone. These form bounding walls of the jointed masses; but the body of the rock is much looser than in the quarry above this one on our walk, indeed on microscopic analysis it shows a preponderance of calcite and zeolites in its composition, while along the footpath above the quarry, steam jet holes of $\frac{1}{4}$ th of an inch or so are distinctly visible. This is Jameson's locality for datholite; though a careful search for boracic acid, by the writer, in the laboratory of the late Dr. George Wilson, in material got here for two months, does not predicate its abundance. Singularly enough, at Corstorphine Hill, another locality for prehnite, harmotome, and pectolite, datholite is also found. The prevalence of these zeolites and their allies in the augitic trappean rocks, as well as their absence from felspathic ones, are characteristic features of the geognosy round Edinburgh.

The "Cats-Nick" at a little hazard may be found a mineralogical treasure-house. Here, Thos. Allan† obtained barite, analcime, calcite, varieties of quartz in colour and form, as also of iron.

Fine specimens of chalcedony were got in a vein, which from its prominence strikes the eye beyond the old quarry, where the Radical Road joins the Queen's Drive beside Holyrood.

A visit to the old quarry in the Hunter's bog behind Salisbury Crags should be undertaken, if only to observe the large constituent quartz crystals of the sandstone.

* *Trans. Ed. Geo. Soc.* Vol. III. pp. 279-291.

† *Trans. Ed. Royal Society*, Vol. VI.

XVII. *On Kyanite Localities in the North.*

By THOS. WALLACE, High School, Inverness.

(Communicated by Rev. W. W. PEYTON.)

[Read June 24th, 1884.]

THE parish of Engie in Banffshire lies on the south shore of the Moray Firth, to the East of the Spey. From the Spey to Buckie on the East the rock is Old Red Sandstone, which extends from the sea inland for about two or two and a half miles. This sandstone area is bounded on the south by a series of clay-slates and mica-schists. Both on the low and high grounds of this little parish, specimens of Kyanite were often picked up, sometimes associated with quartz, and sometimes with the schistose rocks of the district. So far as I have been able to determine, its position *in situ* was not known in the locality until I happened to stumble upon it in July 1882 (see *Trans. Geol. Soc.* Vol. IV. Part III. p. 269), after having examined the Old Red Conglomerates of the "Dramlachs," two streams near Fochabers, remarkable for the sections of conglomerate which they have exposed. Proceeding up the little "Dramlach," until the schist which has been exposed by the entire denudation of the Old Red Sandstone was reached, Kyanite was found *in situ*. The exact locality may be easily found by proceeding along the road from Fochabers to Keith, until the "Little Dramlach," which crosses the road, is reached; following this streamlet until a bridge is reached, Kyanite will be found in the rock on which the bridge is built. It may be remarked that these Eastern schists are in every way more interesting, mineralogically, than the Western or gneissose rocks of the Highlands.* They consist of clay-slates, mica-schists; andalusite, chiastolite, and kyanite-schists; associated with quartzites, serpentines, limestones, diorites, &c. At Portsoy and its neighbourhood the richness of these schists may be easily proved by the great variety of their mineralogical contents. It has been called by one well acquainted with the geology of the Highlands, "a perfect Mineralogical World." Kyanite is also found at Botriphnie in Banffshire, and at Glen Urquhart in Inverness-shire. It is very plentiful in Glen Urquhart, where it is associated with serpentine,

* See *Geol. Soc. Trans.* Vol. III. Part III. p. 338.

anthophyllite, Wollastonite, Biotite, chondrodite, edenite (brown and green), tremolite, actinolite, andesine, feldspar, apatite, sphene, and zoisite.

Staurolite.—These Eastern schists also contain rutile, and I send a specimen of rutile from a new locality, Preshome, in the Engie. The specimen is by no means a good one, not so good as some that I have seen from this locality. It is plentiful here, and better specimens can easily be procured if wanted.

XVIII. *Note on Welsh Gold.*

By T. A. READWIN, F.G.S.

[Abstract.]

[Read June 24th, 1884.]

IN "*Notes on some Minerals of the Mawddach Valley, Merionethshire,*" *Min. Mag.*, Vol. III. p. 122, I referred to their general auriferous character; and to the occasional occurrence of free or native Gold in workable quantity, often in states of Electrum, &c.

Since then I have been experimenting rather largely with the auriferous lode-stuff and its enclosing Silurian slate-rock, just at its junction with the coarse Cambrian (or, it may be, pre-Cambrian) sandstone, about 1,000 feet up the Gwynfynydd or white mountain, ascending from the beautiful waterfalls known to tourists as Pistyll-y-Cain and Rhiadr* Mawddach.

Recently I have made 22 trials upon 58½ tons of the rocks and minerals by amalgamation, and extracted 44½ ounces of gold therefrom.

Altogether, at various times I have made 78 trials upon 72 tons from this mountain, resulting in 118½ ounces of gold, exclusive of rich stones reserved from the treatment, holding about 20 ounces of gold.

These trials were undertaken by me, primarily; to ascertain the relative and intrinsic values of the different minerals, next, an approximate average value, and lastly, the possibility by an eye-test simply, of casting aside some considerable bulk of them as being comparatively non-auriferous.

All this, to a satisfactory extent, I have done; and whilst doing it, have discovered several new and most interesting modes of gold occurrence which I purpose at another time to describe and exhibit to the Society. One of the richest specimens (weighing 160 grains) I have now the pleasure of submitting for examination, partly on account of its singular beauty, and partly in illustration of recent spontaneous gold-growth.

The gold in this beautiful specimen certainly had not its origin in pyritous matter; and it most certainly has undergone appreciable changes of shape since I discovered it last summer.

* Both Pistyll and Rhiadr mean Cascade, on the rivers Cain and Mawddach.

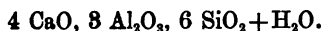
XIX. *Note on New Locality for Zoisite.*

By W. HAMILTON BELL.

(Communicated by the Rev. W. W. PEXTON.)

[Read June 24th, 1884.]

IN the Article "Mineralogy," in the *Encyclopædia Britannica*, written by Professor Heddle, of St. Andrew's, that gentleman gives the formula of Zoisite :—



Alumina 29·8; Lime 24·85; Oxide of Iron 2·8; Silica 40·8; and Water 2·1.) Cleavage, brachy-diagonal, perfect: $H=6$, $G=3\cdot2$ to $3\cdot4$. White, brownish gray, and dark green. Localities, Glen Urquhart, Dalnein (Grantown), and Alt Gonalan, Inverness-shire; Sterzing in Tyrol, the Sau-Alp in Carinthia, the Urals, and Connecticut.

Analysis of Zoisite from Loch Garve, Ross-shire, found by Mr. Hamilton Bell.

SiO ₂	...	...	...	...	42·996
Al ₂ O ₃	...	...	...	...	27·728
Fe ₂ O ₃	...	...	...	...	2·469
CaO	...	...	...	...	24·163
MgO	...	...	...	...	1·403
K ₂ O	...	...	...	...	0·869
CuO	...	...	...	...	trace
					99·628

W. Ivison Macadam, F.C.S., F.I.C., Professor of Chemistry.

In March, 1883, I read to the Edinburgh Geological Society a Paper on matters of geological interest in Eastern Ross-shire, and in it I mentioned that, among other minerals, I had found one which I called Tourmaline. Being a young student even in geology, I was not sufficiently versed in mineralogy to feel satisfied that I was right in this nomenclature; and being at St. Andrew's in autumn last year, I mentioned the matter to Professor Heddle, and showed him a small specimen which I had with me. I had also found in Ross-shire another mineral which I was unable to name, and at Professor Heddle's request I sent him both specimens. I received from him an answer that "both specimens were the

mineral Zoisite," adding, "The brown is like what Dr. Arch. Geikie found at Dalnein Bridge, the white like what I found at Glen Urquhart; the white you have got is in larger crystals than I ever saw before in Scotland;" and then he remarked, "There must be limestone near Loch Garve."

The brown was found in the railway cutting on the Dingwall and Skye Railway, near the "Raven rock," where the rocks are all gneiss and mica-schist plentifully mixed with garnet (Almandine): the white I found in a siding for breaking stones for road metal, close to the station at Garve; and there was fully a ton weight there. I could not then determine its name; but I took away a large quantity. When Professor Heddle stated what it was, I got my friend Mr. Morrison, Rector of Dingwall Academy, to make further search in that neighbourhood, and at a point just above that road siding, and close to a distinguishable mass of pure white quartz, which I had marked, he also found the mineral, but stated that there were no signs of limestone in the neighbourhood, as suggested by Professor Heddle. I also sent a specimen of the brown to Dr. Archibald Geikie, who recognised it as Zoisite, stating "it is nearly identical with the Grantown (Dalnein) variety."

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ADDRESS TO THE MINERALOGICAL SOCIETY.

By the Rev. Prof. BONNEY, D.Sc., LL.D., F.R.S., President.

[Delivered at the Anniversary Meeting, Oct. 21st, 1884.]

It does not appear to be at present a matter of fixed precedent whether the Annual Meeting of the Mineralogical Society should or should not be associated with the delivery of a Presidential Address ; and I had hoped, knowing how slight are my claims to the honour which you have conferred upon me, to have escaped until I give place to a worthier successor. But our Honorary Secretary has intimated to me that he would prefer 'a few remarks,' and as I feel so strongly the obligations under which he has placed the Society by the free gift of his valuable time, his will is law to me.

As the report laid before you justly states, the past year has been a marked epoch in the history of this Society, since it has witnessed the fusion with it of the Crystallological Society. For this

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most fortunate event (as I deem it) we are greatly indebted, I must be allowed to say, to the tact and zeal of our Honorary Secretary. There were not a few difficulties to be surmounted, some susceptibilities to be consulted, but the task was lighter to one so well known in scientific circles than it would have been to many other men of equal energy and zeal for mineralogy.

I have called the event 'most fortunate,' because the existence of two societies so nearly identical in their ends, in fact only differing by the one being nominally more restricted in its means than the other, has always seemed to me a great misfortune. There may be and there sometimes is a healthful effect produced by rivalry; but in science, as in theology, I am afraid that there is always more danger of loss of energy through friction, and even conflict, than hope of gain through a noble emulation. Permanent good, as it seems to me, is only likely to be obtained when of two such societies, the one is content to accept the humbler position, and act to some extent as the helpmate of the other. Certainly we could not expect that this *rôle* would be assumed by a society among whose leading members were the Professors of Mineralogy of Oxford and Cambridge, and the Keeper of the Department of Mineralogy in the British Museum—while we, as far the larger and hardly the less distinguished body, certainly could not be expected to take the 'lower room.'

I think indeed that in all respects I am fortunate in being President at an epoch when the Council are able to present you with such a report as the present; for it also announces that our finances, which two years since were in so critical a condition, have now been restored to a healthful tone; and I trust that by due economy, without any reduction of the real value of our publications, we may be able at the year's end to announce a balance yet more satisfactory.

I find also in the report yet another subject for congratulation, that is, the success which marked the meeting held in Edinburgh last June. There are many advantages attendant on the occasional 'decentralisation' (if I may so apply the term) of a scientific society; and ours, as the number of students of

mineralogy is not large, is exactly one suited for a life mainly settled, but occasionally migratory. I trust, then, that the Scotch meeting will henceforth be an annual occurrence, and I am sure that we may trust to the zeal for fatherland, which in Scotland manifests itself in the nobler instead of the baser form, to make that meeting always a success.

There is one other event of the year to which, although it has no direct connection with our Society, I should like to refer—I mean the rearrangement of the mineralogical collection in the British Museum, which, although it has been the work of more than one year, may be regarded as completed in this by the publication of the Guide to the Mineral Gallery of the British Museum (Natural History). We can now examine that magnificent collection much more easily than in its old home at Bloomsbury. But the feature of the new order of things to which I wish at the present to direct your attention, is the special provision made for the instruction of learners. It is quite true that a willingness to act as public teachers as well as custodians of the national treasures has long been an honourable characteristic of the members of the various departments of the British Museum; and I shall ever remember gratefully the kindnesses which I have received from the late Keeper, Professor Maskelyne, and Mr. T. Davies, in their cramped quarters at Bloomsbury; but the removal of the collection to its more spacious abode at Kensington has given to Mr. L. Fletcher (the present Keeper), with the same able helper, an opportunity which he has been quick to seize, of arranging a number of additional cases, after a distinctly educational plan, and publishing a guide book to the Museum so arranged as to alleviate that overpowering sense of bewilderment with which the beginner (and I may say not only the beginner) contemplates that vast collection. I think, as a teacher myself, I may venture to assure Mr. Fletcher and Mr. Davies of the gratitude of teachers and students alike. The liberality also of the trustees in distributing among places of education their surplus duplicates, many of them specimens of considerable value, though, like silver in the days of Solomon, of little account in that grand collection, calls for a grateful acknowledgment from students.

You will not look to me, gentlemen, for any profound remarks on the subject of Mineralogy. As I vainly urged, when the honour of becoming your President was proposed to me, I am a Petrologist, not a Mineralogist; I pursue mineralogy, if in this place I may dare to make the confession, not so much for its own sake as for the light which it throws upon the constitution and the genesis of rock. I am more concerned with the identification of a mineral, the circumstances of its formation, and its paragenetic habits, than I am with peculiarities either in its form or its chemical composition. Still, from this point of view, a distant one it must be admitted, some things may possibly strike an observer which might not occur to one more profoundly immersed in the study of the subject; and on this account I am about to offer, or perhaps more correctly speaking to reiterate (for they are not new), two criticisms upon systematic mineralogy as it is set forth by many workers. The points to which I am going to refer are to a certain extent questions of nomenclature; but they are more than this—they involve principles, and these of wider application than our science. A word in science should be the expression of a thought, a name more or less the representation of an idea; hence questions of great importance, principles of the highest moment, may often be involved in what at first sight may seem only a matter of nomenclature.

I wish, then, to call your attention to two tendencies among mineralogists, which, as it seems to me, impede the real progress of the science. These are, an over precision, displayed in the notation by a novel name of some slight observed varietal difference in a mineral; and an over laxity in the application of specific names. These tendencies at first sight would appear the outcome of entirely different habits of mind, yet apparently they coexist in the same individual, and possibly find their origin in the same mental idiosyncrasy.

The first—the fondness for giving new names—is only the verbal expression of a habit of species splitting, known in other branches of science, but nowhere I think so rampant as in mineralogy. Open any large work on descriptive mineralogy, and in addition to species you will find its pages studded with named varieties,

some of them quoted only to be rejected by the author, others obviously only distinguished by characteristics which cannot be of real value. To take as an example a single mineral group, the felspars. To begin with, we have a generally admitted difficulty in deciding as to what number of 'major' species (if I may use the term) we shall accept: some authorities even doubting whether *Labradorite* and *oligoclase* can be called 'species,' though I suppose most would agree that they must be in some way designated; many more dispute the claims of *Andesine*; and then we come to forms like *Perthite* and *Bytownite*, obvious mixtures of more than one species, and a crowd of others, such as *Indianite*, *Huronite*, *Tschermakite*, *Hafnefjordite*, *pericline*, *loaxoclase*, *Murchisonite*, *Carnatite*, *hyposclerite*, *erythrite*, &c.

I do not deny that in these and similar cases with regard to several other minerals which it would be easy to quote, the names often express some variation either in aspect or mineral composition or look, of which it may be well to take note—as, for example, the peculiar bloom of *peristerite*, or the rather exceptional composition of *Bytownite*; but I object to giving to these a distinctive name instead of a distinctive epithet. This may seem at first sight a trivial criticism—to object to *peristerite*, and prefer such a term as opalescent or chatoyant *albite*, may seem to be choosing the more cumbersome instead of the more concise appellation, but I think there is a question of principle involved: the one nomenclature accentuates the distinction, and loses sight of the relation; the other, while noting the distinction, keeps prominent the relationship. This has an inevitable mental influence; diverse names mean diverse mental pigeon-holes; by giving a thing a separate name we tend to give it a separate entity as a conception. To give a rough example: I am distinguished from my brother by a separate christian name, and identified with him by the same surname; if I changed the latter, the bulk of people—all but the few who knew us intimately—would forget that we were related, and the world at large (assuming for a moment that such insignificant beings could attract notice) would be perplexed at the visible resemblances. He who augments the lists of minerals by naming a dubious

species, depend upon it, confers the reverse of a boon upon his science. If we acted on the same principle in petrology, we should exhaust the Greek lexicon or the parish lists in our search for names. I remember, indeed, some years back an ardent mineralogist, who, straying into petrology, got hold of two or three varieties of felsite, each perfectly common types, and thoroughly well known to petrologists as of wide distribution, and proceeded to confer upon them barbarous names from some outlandish villages in Britain. I have often wondered how many new species he would make out of my collection. But seriously, this tendency to individualism (not, I fear, without some root in human vanity) tends to promote a mental habit very fatal to real progress in science. It may be described in the homely phrase "not being able to see the wood for the trees." The great end of science is to determine principles and seek after laws. In the search for these distinction is in reality only a step in the process of correlation; a classification founded only on divergences would be universally admitted to have no philosophical basis. All great generalisations are made by discussing the resemblances which underlie the apparent divergences, tracing (as it were) the many distinct twigs back to the one parent stem; correlating facts, correlating phenomena, correlating principles, till they can be shown to be the result of general laws, the outcome of the forces or force of which all nature is the result.

The second point to which I desire to draw your attention seems at first sight exactly the opposite to the last mentioned. This is, a laxity in our system of classification, by means of which the mineral 'species or genus,' if I may be allowed the phrase, is made too inclusive; or, to put it more clearly, many substances are called minerals which have no real claim to the name. It is of course difficult to frame in a few words a perfectly unexceptionable definition of a mineral; but it may be described as an inorganic substance, a possible constituent of the earth's crust, distinguished from its fellows by certain definite characteristics of form, structure, and chemical composition. In regard to the first and second of these three characteristics we have to allow of some laxity in order to admit certain minerals of indefinite form,

such as opal; and in the case of the last considerable latitude is sometimes necessary because of isomorphic replacements among the chemical constituents. Still we are able to attach a fairly exact meaning to the definition of a mineral, and the difficulty here is no greater than that which frequently confronts us in the Natural Sciences. For an example, then, of the defect which I mean, I will again refer to the felspars. In some of our best text books of mineralogy I find set down under the head of "an amorphous form of orthoclase" *pitchstone* and *obsidian*, to say nothing of other substances yet more open to objection. Now, what excuse is there for terming these substances *minerals*? They have no definite form, for they are glasses, they are more or less composite in habit, and their variations in chemical composition far exceed the possibilities of isomorphic replacements. Take any table of analyses of these volcanic glasses, and you will see by a simple calculation, I might even say at a glance, that they contain much more silica than could be used up in forming a felspar; so that, if the materials were crystallised you would have a felspar with an admixture (and that a very variable one) of free quartz. Nay, I have even seen crowded together in one list under the head of 'orthoclase,' volcanic glasses which one can see from a mere study of the analyses (apart from any knowledge one may have otherwise acquired) represent mixtures of quartz and orthoclase, or of quartz and albite or oligoclase with a little of a magnesian mineral (hornblende, augite, or biotite), and mixtures of labradorite or anorthite, without any quartz and with a considerable proportion of the above magnesian minerals. I grant that these glasses, with such rocks as felsstone, are commonly inserted rather apologetically, but my contention is that the student ought not to be confused by seeing them classed as *minerals* at all. They should be quoted as *rocks*, into the composition of which such and such minerals, visibly or invisibly, enter. In like way coal has no claim to be ranked among minerals; and I think that it would be much better to designate even chalcedony, flint, chert, agate, jasper, &c. as mineral aggregates (*i.e.* rocks), into the composition of which microcrystalline quartz very largely (sometimes exclusively) enters. I need not occupy your time by increasing the list of examples of this confused thinking, though it would not be difficult.

In justification, and to point the moral of these criticisms, I will make one more, speaking now as a petrologist. It is that, as a rule, we find the man of science, who is mainly a mineralogist, less helpful than we should have expected, nay, that sometimes he leads us into darkness rather than light. Perhaps I may be pardoned for giving one or two examples. In petrology the question of genesis is obviously one of the most important; yet mineralogists (I suppress names because I do not wish to attack individuals) have proposed classifications which group together such rocks as eclogite and Lherzolite simply on the ground that they are without felspar; but the former contains a considerable quantity of alumina, and if always an igneous rock (more work is still needed among the massive garnetiferous rocks) is obviously nearer to the diorites; while the latter contains hardly any alumina, and belongs to the peridotites or olivine-rocks, a group as well marked as any other in Nature. By the same author chlorite-schist and serpentine are grouped together—a more pardonable alliance indeed, but objectionable inasmuch as the former when typical is always in some sense or other a stratified rock; the latter, when typical, always to be traced back to a member of the peridotite group, which, like the dolerites, are of igneous origin. I am aware that this last statement will be disputed by some mineralogists, but I am perfectly confident of its accuracy as long as the terms are used in an exact sense. With regard to serpentine, indeed, there have been found mineralogists who in preference to this obvious and natural derivation from a peridotite have claimed for it a parentage, by some strange process of metamorphism or rather methylosis, from gabbro, diorite, hornblende-schist and the like, nay even from granulite and granite. Now confusions like these arise from the mental habit to which I have already alluded; too great concentration on minutiae has prevented the investigator from grasping the problem as a whole; the processes of change are neither apprehended in their progressive aspect nor duly weighed in the scale of probabilities; while superficial similarities blind the eyes to underlying dissimilarities. I have noted more than once that such a one has taken up this question without attaching any definite meaning to the terms

which he is using, and is asserting transmutations from one rock to another without giving any evidence (nay, with the strongest indirect evidence to the contrary) that he has ever brought to a crucial test those parts of the rock where the key of his position is hid; nay, apparently he not seldom appears to have undertaken the investigation without any knowledge that such a key must exist, and that it is his bounden duty to find it.

I trust I may be forgiven for the bluntness of these remarks; but, after devoting for some fourteen years all the time and money I could spare to trying to come at the truth in petrology, I may perhaps be forgiven for complaining that we petrologists receive as large a proportion of crude speculations and of unproved and unprovable statements from mineralogists, who should be exact investigators and close reasoners, as we do from the field-geologist, who barely knows quartz from felspar, and regards a microscope much as a certain person looks upon holy water. That this has happened, and that the science of mineralogy is in some other respects less progressive than it should be, is, I believe, largely due to those two defects to which I have ventured to call your attention.

Fine Crystals of Pale Lilac Calcite from Tankerville Mine, near Shelve, Shropshire.

By R. H. SOLLY, F.G.S., Demonstrator in Mineralogy to the University of Cambridge.

[Read October 21st, 1884.]

THE rare occurrence of the primitive rhombohedron r {100} with little or no modification on crystals of calcite has induced me to bring to the notice of the Society some very fine pale lilac crystals exhibiting this unusual habit.

These specimens were raised a few years ago from the Llandeilo flags strata in the Tankerville lead mine, near Shelve, Shropshire.

Usually the crystals are in small groups, not more than three or four together, and these are invariably twinned as penetration twins according to the law o {111} as twin-plane, and somewhat resemble twins of fluor spar, from the even development of the r {100} faces.

On these specimens the {100} faces are nearly equally developed, and are only modified by the scalenohedron v {201}, a narrow plane about a sixth of the size of the r planes. They often measure 11 mm. along the morphological axis, and a little less in a direction at right angles (fig. A.).

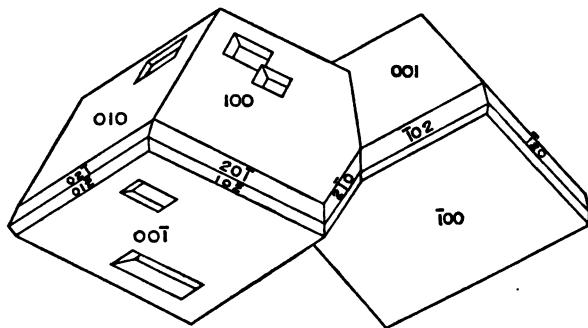


FIG. A.

Small limpid crystals of quartz coat the v planes, while on the r planes it is rare to find even a single crystal of quartz, though minute ones are found dispersed throughout the crystals.

The r planes are dull and slightly corroded, and often have cleavage rhomb-shaped pits on their faces, while the v planes are bright and

smooth, the quartz crystals having acted as a protection to the corroding fluid which destroyed the lustre of the r planes; but why the quartz crystals were deposited on the v planes by preference is apparently inexplicable.

A cleavage fragment was detached from one of the specimens, and after careful selection, a small brilliant fragment was measured on a Fuess goniometer, with the highest power. It gave a very bright reflection of the Websky slit, and the following readings.

The faces were within half a minute parallel to one another, and the two brightest images gave

$$rr\ 105^{\circ} 4\frac{1}{2}'. \text{ Miller, } rr\ 105^{\circ} 5'.$$

The scalenohedron form was determined from the crystal itself across bb''

$$v\bar{v} = 47^{\circ} 80'. \text{ Miller, } v\bar{v}\ 47^{\circ} 2'.$$

Since these specimens were raised, a very fine mass of crystals has been found in the same mine; this is worth describing.

It measures about two yards in circumference; the matrix is a thick layer of stout limpid quartz crystals, on which are deposited some half-a-dozen fine large crystals of lilac calcite, slightly polysynthetic in growth, similar to those described above; and also three or four large polysynthetic cubes of galena about one and a half inches square, beautifully tarnished, associated with a little copper pyrites and brown blende crystals. About the same time fine limpid white botryoidal calcite was discovered at the Roman Gravels, a mine adjoining. A fine specimen of calcite from the Camborne district, Cornwall, unique of its kind, is in the possession of Mr. Thos. Cornish, of Penzance. The crystals are white and semi-transparent, exhibiting the same development as those from the Tankerville mine. They are about an inch in diameter, and speckled on one side only by brilliant tetrahedra of copper pyrites.

The description of these specimens leads to a consideration of the cause of the numerous simple and modified forms of calcite. Dr. Irby, in his monograph on calcite, says that only one-seventh of the specimens he has examined have $r\{100\}$ in combination with other forms, and as a simple form it is extremely rare.

Credner also found, when making artificial crystals of $CaCO_3$, that $r\{100\}$ predominated more frequently over the other forms when the crystals were obtained from pure solutions than when foreign substances were introduced. But the question arises, why should a trace of Mn be generally found in $r\{100\}$ crystals, as shown by the Tankerville, Iceland and Dauphiné crystals; also why should a trace of Mg be generally found in $e\{100\}$ crystals, as shown by the "nail-head" calcite of the north country,

and a trace of Fe in $v\{20\bar{1}\}$ crystals, as shown by the "dog-tooth" scale-nohedra of Derbyshire?

Possibly the answer may be that an infinitesimally small portion of an isomorphous chemical substance, when chemically combined, is able to induce a particular form.

Credner's experiments on the highly modifying influence of silicate of potash when introduced into the liquor, by which he caused numerous forms to grow on his artificial crystals of calcite, led him to infer that the presence of analcime with the crystals of calcite at Andreasberg and Lake Superior played the same part in the laboratory of Nature.

But the common "cannon spar" (hexagonal prism with basal plane) from the silver mines of Andreasberg is associated with the same minerals as the highly modified specimens. It seems, therefore, that we require more instances before accepting this proposition.

Another explanation offers itself in the effect of mechanically mixed impurities in modifying the form of a crystal, but the difference between the *density* of the impurity and that of the crystal may also affect the modification. For the large inclusion of quartz (sp. gr. 2.65) in the Fontainebleau calcite crystals (sp. gr. 2.72), and the fairly numerous crystals of quartz in the Tankerville crystals seem to accompany a simple form, while the native copper (sp. gr. 8.7) enclosed in the calcite crystals of Lake Superior accompanies very complicated forms. Or the answer may be that impurities, whether chemically or mechanically mixed, have little or no modifying influence, and the rate of deposition or the temperature of solution is rather the ruling force which governs the ultimate form or forms.

The crystallisation of certain artificial salts seems to show that the slower the growth the greater is the modification.

Again, the liquor in which a crystal is grown sometimes governs the form, as seen when crystals of alum are formed in urine, since alum crystals when grown in this manner give cubes, and rock salt octahedra.

The experiments on variation of temperature in modifying the form of artificial crystals seem to point to a complexity of form accompanying increase of temperature.

The result of the numerous experiments on the dimorphism of $CaCO_3$, makes it difficult to allow that the temperature, rate of deposition, or inclusion of impurities, are the whole cause of the numerous simple forms in calcite, since these experiments show that crystals of aragonite are formed at a high temperature, and even at a low temperature when the liquor contains gypsum or strontian.

There is still another cause to be mentioned—the effect of magnetic and electric currents on the growth and form of crystals—forces which after all may have more to do with the ultimate form than either temperature, rate of deposition, impurities, &c. We seek, alas, in vain for assistance in solving the question from any laboratory experiments at present published.

Thus all experiments on growing artificial crystals do not help us to understand why calcite should crystallise in different simple forms, which are characteristic of certain localities; though the fact may possibly be accounted for by the different degrees of resistance that the beds and vein-stone may offer to the magnetic or electric currents while the crystals are growing.

Description of a Crystal of Parisite.

By Monsieur GUYOT DE GRANDMAISON.

[Exhibited October 21st, 1884.]

OCCURRENCE. At the Emerald Mines of the Valley of Muso, New Granada, in a gangue composed of anthracitic calcite and pyrites. Lustre, vitreous to resinous; colour, yellowish brown to honey-yellow. An acute hexagonal pyramid with striations perpendicular to the axis. The crystal measures 84 millim. in length, and 12 millim. in thickness at the base.

The pyramid is perfect and its apex is intact.

All the specimens of Parisite which have been hitherto received, and are found in European Museums, exhibit a truncated hexagonal pyramid. This section is due to a very easy basal cleavage.

Further Notes on Enargite.

By W. SEMMONS.

[Read October 21st, 1884.]

WHEN I submitted my Paper on Enargite (*Min. Mag.* Vol. vi. p. 49) to this Society, I was unable to give the exact locality of the mineral. As the territory of Montana embraces a considerable extent of land, I was therefore desirous of ascertaining the position of the mines yielding the ore.

Having during the past summer had the opportunity of visiting the locality, I am now able to give some further particulars.

I have found it at the Liquidator Mine in Silver Bow county, near Butte City, also at the Gaquon mine. At the Liquidator it is associated with iron pyrites, Covellite, and Bornite, and seems to constitute a large proportion of the ore raised.

At the Gaquon mine it is associated with chalcocite containing silver. I did not find any at the famous "Anaconda" mine; but as they were then working on the rich lead of the lode (only a portion thereof) which was almost a pure chalcocite, containing about 35 oz. silver per ton, it is quite possible that the mineral will also be found there.

I also found it in the Parrot and Colusa ores, although these are as a rule free from arsenic.

The mineral therefore seems rather widely diffused, and as I was informed on good authority that it was also found near Marysville, in Lewis and Clark county, it is probable that it is rather a common ore in the district.

The specimens from the Gaquon mine are interesting, as they show several crystals. Some are rhombic prisms about $\frac{1}{4}$ inch across and $\frac{1}{4}$ long, with only the prism and basal pinacoid developed, while others are truncated, and thus give some planes of the pyramids. The very perfect cleavage and deep striations are characteristic of the mineral throughout the district.

As these deposits of Montana are comparatively superficial, I searched very earnestly for some indications of decomposition and its results; for, as all mineralogists well know, it is here we may look for interesting and new compounds. I was unable to meet with anything however in the locality, but in some ores from the Mammoth Copperopolis mine in Nevada, where

I also found some Enargite in a decomposed state, we meet with several minerals of extreme interest.

I have here specimens of olivenite, Chenevixite, Cornwallite, conichalcite, from this mine, also probably Bayldonite, though as I have only the simple blowpipe tests to rely on, which confirm the rough determinations of my mining friends in America, I do not feel certain that all these names will be maintained after chemical analysis. They are undoubtedly hydrated arseniates of copper, and some contain lead. Olivenite and Chenevixite are certainly there, but as for the others I am not positive, though I do not care to dispute the miner's determination; cacoxenite also appears to be present.

About ten years ago, a sample parcel of ore from Mammoth Copperopolis was sent to Liverpool, which yielded a high percentage of copper. From this I obtained azurite, chrysocolla, and another copper mineral which then puzzled me extremely. I found it was an arseniate of copper with chloride of copper intermixed. It was with pleasure I found, about two years since, that there was an almost similar specimen at the British Museum, labelled Cornwallite. It is probable, therefore, that a considerable quantity of this mineral has been raised during the past decade from Nevada.

Enargite has thus been found in most of the states and territories lying about the range of the Rocky Mountains, and I fully expect to hear of our American friends finding some remarkable combinations, when this ore is found in close proximity to their seemingly boundless deposits of lead minerals.

Some Occurrences of Actinolite in Scotland.

By Rev. W. W. PEYTON.

[Read June 24th, 1884.] (Abstract.)

IN this Paper the author directs attention to some localities in Scotland where the actinolite forms of hornblende are to be found.

In Aberdeenshire the actinolite occurs as sheaf-like groups, irregularly distributed through a felspathic base; also as slender crystals, extending sometimes to the length of eighteen inches, in a dioritic rock. On the hill of Heshgarnich, in Perthshire, this variety of hornblende occurs in nests, also in fan- or sheaf-like bundles of a black colour; and on the north side of the hill it is found in blade-like forms distributed through a glistening micaceous schist.

Various textured schists in Strathmore enclose irregularly distributed crystals, which are mostly small and dark green in colour.

A whitish unctuous schist in the vicinity of Blairgowrie, Perthshire, contains innumerable crystals of a colour ranging from dense green to almost black.

About two miles from Portsoy, Banffshire, a black micaceous schist occurs, in which the similarly coloured actinolite forms a glistening constituent. The actinolite here resembles that of some of Strathmore.

The gneissose rocks of Colefirth Voe, Mainland, Shetland, in addition to the ordinary hornblende forms, contain sheaf to fan-like and also acicular actinolite.

Observations on the Preparation of Mineral and Rock Sections for the Microscope.

By JOHN ERNEST ADY.

[Read December 9th, 1884.]

DURING the past few years the study of the minute structure of minerals and rocks has received the attention of so many able geologists, that microscopical mineralogy and petrography may now be regarded as a fairly established means for the identification and diagnosis of inorganic species. As a special instance, I may point to Heddle's researches on Amazonstone,* where the discrepancy of its chemical constitution from normal orthoclase, and its aberrant crystalline form, are accounted for under the microscope, with polarised light, by minute structural peculiarities which support the view that it is composed, not of orthoclase and albite, as has been supposed, but of orthoclase and a paragenetic constituent, allied to, if not identical with, oligoclase.

I propose to confine my remarks to the preparation of hard substances which do not require any special previous or after treatment to enable them to withstand the mechanical methods to which they are subjected. There are many trifling details of manipulation, the neglect or observance of which suffice to draw the line between failure and success. By the term failure I intend to imply that slovenly habit of securing a thin fragment of a section and mounting it anyhow, with clinging particles of dust and dirt, to which such errors of observation as a detailed description of rough surfaces, rugosities, striæ, cavities filled with unknown products, and a variety of other conflicting evidences, are to be attributed; whereas a successfully prepared section, in the hands of a faithful recorder, can only contribute to the advancement of science.

Although my present communication will not involve any novel principles, I trust that, by a formulated outline of the best known methods, divested of all unnecessary and extravagant details, and supplemented by practical notes, to place before the Society the most noteworthy results of my experience.

* *Trans. Roy. Soc. Edin.*, Vol. XXVIII. p. 197 *et seq.*; *Min. Mag.* Vol. V. 1883, p. 160 *et seq.*

The first operation in the preparation of sections is to secure a slice of the mineral or rock. In the former case, it is obvious that for purposes of investigation a definite series of sectional planes should be selected; in the latter instance, especially in very finely-textured rocks, without any natural or superinduced peculiarities, such as occur in finely laminated examples, slates, schists, &c. or the presence of specially developed and local particles, the plane of section is immaterial, and a chip taken with a hammer may often suffice. The process of slicing by hand, with emery powder and a toothless tenon-saw, is both tardy and extremely laborious. The employment of a slitting machine, fitted with a diamond-charged disc of soft iron (the so-called block tin), is an accomplishment which requires considerable practice, and indeed is not worth while adopting for the production of a few occasional slices, except to gratify the whim of the worker, since they can be both efficiently and inexpensively cut by any good working lapidary.*

The reduction of the slice may be accomplished by hand, or with the aid of a grinding bench. In either case, the processes are essentially the same; the result to be aimed at is, a section of the desired thickness, which shall be perfectly even and free from superficial scratches. The tenuity of the preparation must of course be regulated by the special requirements of each case; as a rule, however, the thinner a slice can be made, the more valuable it becomes to the general investigator, especially with high powers of the microscope; minute endomorphs, cavities, and traces of fluidal structure may thus be revealed, and inferences often of great importance deduced therefrom. Sections of finely textured and dark rocks, such as the majority of the basalts, dolerites, &c., may be roughly gauged by placing them over a sheet of ordinary printed matter; if the typographical characters can be readily distinguished, the specimen may be regarded as sufficiently thin. Another somewhat more reliable ready expedient is, to hold the preparation near to the eye between it and a window or other object illuminated by diffused light; if the outlines of the window-frame and bars can be easily distinguished, the section may be taken to be adequately thin. Translucent and transparent minerals, or rocks composed of a large proportion of such constituents as quartz, clear felspar, or calcite, may be reduced until the darker minerals with which

* I usually mark my mineral specimens with lines of ink, to which a little mucilage has been added, to indicate the directions along which I desire to have them sliced. Rocks and dark opaque minerals may be marked with a fine camel's hair brush dipped in artist's oil-vermilion, reduced to a suitable consistency with benzol.

they are generally associated, *e.g.* hornblende, mica, schorl, augite, &c. become almost transparent. In themselves, however, the intensity of chromatic effect, when viewed with polarised light under a low power of the microscope, is a sufficient test. A basalt thus examined ought to reveal the intimate structure of its interstitial groundmass, and the granular condition of its augite ought also to be clearly defined; whilst the closely aggregated patches of dark spicular schorl in the variety Luxulianite should be resolvable into stellate groups, each with distinct radii. The individual grains of limestones and sandstones ought to lie in a single layer, so as to avoid interference phenomena, and the fluid cavities of milky quartz admit of coming into focus under the highest magnifying powers that are of any use.

The mode of preparing hard sections is briefly as follows :—The slice or chip must be ground absolutely level and perfectly smooth on one side; it is not necessary to polish the face. The smooth facette may thereafter be firmly cemented on to a suitable piece of glass, and the other side then reduced until a sufficiently thin section is obtained. To do this by hand, a few soft metal plates, preferably of pewter, zinc, copper, or lap-metal, each about 12 inches square, and $\frac{1}{4}$ inch thick, three sizes of emery powder, and one or two Water-of-Ayr hones, are in reality all that is necessary. Glass plates are not to be tolerated, since they rapidly wear away irregularly unless extreme care is taken. For the final operation of grinding, flour-emery which has been used and washed, or mirror-polishers' powder, is to be preferred.

(I.) Oakey's No. 60 hole emery powder with a little water should be used upon one of the soft metal plates, and the slice may by a small circular motion over each quarter of the plate, and a gradual transition into a greater circular motion thereafter around and towards the centre of the plate, be ground coarsely level on one side, and prevent the plate from wearing away into hollows. This operation should be repeated on another plate with No. 80 hole emery, and then on another with flour emery; care should be taken to wash the section thoroughly each time before using emery of a different size.

To produce a perfectly flat face upon the slice, the surface of the plates should be slightly raised at their centres so as to be somewhat convex. This may be produced by heating the central part over a spirit or Bunsen flame, when the four corners of the square will tend to bend slightly downwards, and give the desired degree of convexity to the upper grinding surface. The plate may then be fixed upon a support of wood

covered with a layer of plaster of Paris, so as to prevent a springing motion during the process of grinding.

(II.) The use of flour emery will secure a tolerably smooth surface, free from any serious scratches or roughness; but it is advisable to make use of a Water-of Ayr hone, with a plentiful supply of water, in addition, to ensure success. Indeed, *two* hones may be advantageously employed, and their surfaces are to be specially prepared beforehand thus:—The first hone, about 6 inches long and $1\frac{1}{2}$ inches in breadth, is to be rubbed rapidly from end to end, longitudinally in one direction, upon a level slab of fine sandstone. This will develop a slightly convex surface upon the hone. The second hone, of similar proportions, must be treated in the same way, but it should in addition be further rubbed upon a slab of fine marble, so as to secure a smoother surface also slightly convex. The value of a convex grinding or polishing surface where the pressure is applied by the hand has long been known to practical mechanicians, for it is upon this principle that the so-called engineer's file is constructed. To the neglect of this item may be traced the cause of those inequalities which result in a section thick towards the centre and thin at the edges.

(III.) In fastening the smoothened surface of the slice to a piece of glass, the best cement substance I have found for the purpose is that made of an admixture of Venice turpentine and orange shellac. The turpentine should be heated in a sand or water bath, and enough shellac ought to be added to it to produce on cooling a thoroughly hard yet tough solid; it may be tested from time to time by the removal of a small portion. The advantages of this cement are manifold: it is not prone to imbed particles of emery during the processes of grinding, its adhesive properties are exactly suited to the requirements of the case, and it is perfectly soluble in ordinary methylated spirit. By surrounding the edges of the slice with a small quantity of the cement, the borders of the latter will be perfectly protected.

The slice ought to be fixed on to the small preliminary square of glass, with the fastening substance melted upon it over a spirit or Bunsen flame; it should be firmly pressed upon the glass slip (which, by the way, is all the better for being made of the best flattened plate glass, about $\frac{1}{4}$ inch thick, and $1\frac{1}{2}$ inches square) to the entire exclusion of air-bubbles.

(IV.) The process of reduction may be carried on with Nos. 60 and 80 hole emery powder, until in dark specimens, *e.g.* basalts, &c., the slice becomes translucent. Flour emery may then be used, and the final touches given upon the Water-of-Ayr hones. During the latter stages, the specimen ought to be repeatedly examined under the microscope.

(V.) All that is necessary now is to remove the finished section from the preliminary slip of glass. This may be best accomplished by soaking it in a saucer full of methylated spirit. The slice ought to float off of itself in the course of a few hours ; it must not any account be forced off. After detachment, it should be transferred to a dish of clean spirit for an hour or so, and gently washed therein with a fine camel's-hair or sable pencil.

(VI.) From the clean spirit the slice should be removed by means of a special lifter (a fine brush or stout needle will do), and placed between slips of clean white tissue paper, where they will dry rapidly and be ready for mounting.

(VII.) The best mounting fluid for rock sections is a filtered solution of equal parts of Canada balsam and gum damar in pure benzol. Hardened Canada balsam dissolved in benzol and filtered may also be used. A drop of the solution ought to be placed upon a clean warmed slip of glass, the section placed therein covered with another drop, and laid aside for about 10 or 12 hours in a dust-proof box, or under a bell glass. This process, which I have described elsewhere as the "*exposure method*," permits the medium to assume a suitable consistency before the cover glass is applied to the preparation. After exposure, a fresh drop of balsam may be placed upon the section, and a gently warmed cover glass lowered upon the whole.

I may state that balsam prepared in the manner indicated, and used after the method I have described, will enable the operator to cleanse his preparation of all superfluous balsam *immediately* after he has placed the cover glass thereon, by simply rubbing it with a rag dipped in methylated spirit. Air bubbles and vacuoles, moreover, may be disregarded, as the nature of the medium is incompatible with their persistence.

The labour of grinding sections of minerals and rocks for the microscope by hand is so tedious, that few persons would follow that process where they could resort to a suitable grinding bench. Many instruments have been devised for this purpose, the best one in the English market being that of Messrs. Cotton and Johnson, and called the "*Amateurs' Lapidary Machine*." There is room, however, for vast improvements in instruments of this kind; those that are now made for scientific inquirers are either too expensive or mere toys; whilst working lapidaries use benches which require almost a term of apprenticeship to enable one to manage them. What is wanted by the petrologist is a thoroughly good machine with a horizontally disposed fly-wheel, treadle action, firm steady bearings, and the entire system so arranged as to admit of the ready change of laps, and the cleanly application of emery with the greatest possible utility.

I am glad to be able here to describe a machine which fully meets all the wants I have just enumerated, and which has hitherto remained unnoticed. With its aid several hundreds of sections of the most perfect description were prepared in illustration of my journal on microscopical petrography.

The vertical treadle motion is modified into a powerful horizontal one by means of a strong cord passed over a pulley, and attached to the crank of a fly-wheel. A connecting strap transfers the motion of the fly-wheel to a small horizontally placed spindle-bearing wheel. The lower end of the spindle works upon a fixed iron bearing, whilst its upper extremity is free and slotted to receive the central attachment pins of the grinding discs. The circular grinding discs are provided with cylindrical rod-like attachment pins screwed into the centres of their lower faces at right angles thereto; they are simply allowed to slide into the receiving slot of the spindle-head, and can therefore be readily changed; their weight, and the pressure applied to their upper surfaces during the process of grinding, are sufficient to maintain them firmly. The fly-wheel works between two metal bearings supported by a strong framework, which can be made to slide forwards or backwards in the body of the bench by working a large adjustable wooden screw; thus, when the connecting strap becomes somewhat slack, it can be speedily tightened by merely turning the screw-head.

Before placing the lap into the slot of the spindle-head, the waste emery box must be placed around the latter, and over this a protecting metal cup-shaped cap is slid to prevent the possible passage of dirt to the working parts of the instrument.

Lastly, the subjoined figures with explanatory notes and measurements will show the details of this new lapidary's lathe far better than any verbal description alone. It may be taken as a working plan.

EXPLANATION OF PLATES.

Plate III.—Diagrammatic Sectional Drawing of Lapidary's Lathe for Petrographical Work. *T.*, Top of table; *u.u.*, upright supporting legs; *J.*, middle joist; *tr.*, treadle; *cd.*, cord of treadle passing over pulley wheel (*p.w.*) to crank (*cr.*) of fly-wheel (*f.w.*); *st.*, strap from fly-wheel to spindle-bearing wheel (*sp.w.*); *Sp.*, upper end of spindle; *Sp. 1.*, lower part of spindle resting on bearing (*Sp. B.*); *u.b.*, and *l.b.*, upper and lower bearings of fly-wheel, sunk in sliding-frame (*fr.*), which can be regulated by wooden screw (*u.s.*). The lower bearing, along with the inferior arm of the sliding frame, move in a limited groove in the joist (*J*), which is specially morticed at this part.

Plate IV.—Enlarged Diagram of Grinding Apparatus. *i.*, Circular brass ring bordering aperture for upper end of spindle (*Sp.*); it is provided with an upward projecting rim. The brass cap (*c*) acts as a steadying bearing to the spindle head (*Sp.*); *i'*, circular metal ring with upward projecting rim fastened on edge of central aperture of waste emery box (*b*); the brass protecting cap (*p*) comes over the edge of this rim, and is apposed above to the free extremity of the spindle-head, thus effectually preventing the entry of dirt to the bearing (*c*); *i''*, iron pegs for securing box (*b*) in its place. *L.* lap, or grinding disc; *a.*, attachment pin of lap, is somewhat conical, and does not quite fill the slot (*s*); thus providing a grip which tends to become more firmly fixed during the process of grinding.

WORKING MEASUREMENTS.

Table	{	Height	88 inches.
		Length	40 inches.
		Width	20 inches.

Distance of joist (<i>J</i>) from top of table	6 inches.
Distance of spindle from nearest supporting leg (<i>u</i>) ...	5 inches.
Diameter of fly-wheel	16 inches.
Diameter of spindle-bearing wheel	6½ inches.
Diameter of pulley wheel	5½ inches.
Length of arms of sliding frame (<i>fr</i>)	10 inches.
Side of square waste emery box (<i>b</i>)	12½ inches.

INDEX TO MINERALOGICAL PAPERS, &c. 1888.

By H. A. MIERS, M.A.

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(FIRST PART.)

-
- ADULARIA. F. Pfaff. Ber. Ak. Münch. p. 65. *Hardness.*
- ALBITE. C. Bärwald. Zs. K. viii. p. 48.
- ALBITE & OLIGOCLASE. A. Descloizeaux. Bull. Soc. Min. p. 89. *Optical Constants.*
- AMALGAM. Dechen. Ber. Nied. Ges. Bonn. p. 41. *Chem.*
- AMAZONSTONE. M. Heddle. Min. Mag. v. p. 158. *Sutherland.*
- AMETHYST. H. Böklen. N. J. (1), p. 62.
- AMELIA CO. VIRGINIA. W. Fontaine. Am. J. Sc. xxv. p. 330. *Minerals of.*
- AMBER. G. Kunz. Trans. New York Ac. ii. p. 85. *New Jersey.*
- AMPHIBOLE. N. Kokscharow. Bull. Ac. St. Pet. xxviii. p. 19. *Cryst.*
- ANATASE. G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
- ANDALUSITE. G. Kunz. Proc. Am. Ass. p. 270. *Loc.*
- ANHYDRITE. O. Mügge. N. J. (2), p. 258. *Artificial Twinning.*
v. Barytes.
- APATITE. G. Starkl. Jahrb. Geol. Reichs. p. 643. *Christianberg.*
A. Schmidt. Zs. K. vii. p. 551. *Cryst.*
C. Hintze. Zs. K. vii. p. 590. *Cryst.*
F. Pfaff. Ber. Ak. Münch. p. 64. *Hardness.*
W. Lewis. Nature, xxvii. p. 608. *Cryst.*
S. Henson. Min. Mag. v. p. 198. *Salzburg.*
W. Hankel. Abh. Sächs. Ges. p. 1. *Thermoel.*
- ARKSUTITE. P. Groth. Zs. K. vii. p. 479. *Min.*
- AUGITE & AMPHIBOLE. A. Kenngott. N. J. (2), p. 171. *Chem.*
- AXINITE. W. Hankel. Abh. Sächs. Ges. p. 46. *Thermoel.*
- BARYTES. F. Grünling. Zs. K. viii. p. 243. *Binnenthal.*
H. Miers and C. Woodward. Nature, xxix. pp. 29, 77, 124.
Cryst.
- BARYTES, CELESTINE, }
ANHYDRITE. } Dieulafoy C. R. 97, p. 51. *Min.*
- BAUXITE. W. Will. Ber. Oberhess. Ges. xxii. p. 314. *Chem.*
S. Meunier. C. R. 96, p. 1737. *Min.*
- BELONESIA. A. and E. Scacchi. Rendic. Ac. Nap. p. 282. *New Min.*
Vesuvius.
- BERTRANDITE. E. Bertrand. Bull. Soc. Min. p. 248. *New Min.*
A. Damour. Bull. Soc. Min. p. 252. *Chem.*

- BERYL.** G. Kunz. Proc. Am. Ass. p. 275. *Maine.*
N. Kokscharow. Bull. Ac. St. Pet. xxviii. p. 35. *Cryst.*
v. Cassiterite.
- BIGORRE.** C. Frossard. Bull. Soc. Min. p. 85. *Minerals of.*
- BIOTITE.** G. Starkl. Jahrb. Geol. Reichs. p. 639. *Christianberg.*
- BISMUTHITE.** v. Gypsum.
- BITUMENS.** M. Boussingault. Ann. Chim. Phys. xxix. p. 363. *Chem.*
- BLENDE.** F. Becke. Min. Mitth. v. p. 457. *Etching.*
G. Freda. Rendic. Ac. Nap. p. 292. *Chem.*
O. Friedel and J. Curie. Bull. Soc. Min. p. 191. *Pyro-el.*
v. Tetrahedrite.
- BLENDE, BORACITE.** W. Will. Ber. Oberhess. Ges. xxii. p. 315. *Chem.*
- BLENDE.** K. Mack. Zs. K. viii. p. 503. *Pyro-el.*
- BOLE.** E. Mallard. Bull. Soc. Min. pp. 122, 129. *Latent Heat and Indices.*
- BORACITE.** v. Blende.
- BROCHANTITE.** M. Websky. Ber. Ges. Nat. Fr. Berl. p. 99. *Nischni-Tagilsk.*
- BRONZITE.** H. Bücking. Zs. K. vii. p. 502.
- BROOKITE.** G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
- BRUCITE.** Max Bauer. N. J. Beil. Bd. p. 49. *Index of Refraction.*
W. Hankel. Abh. Sächs. Ges. p. 20. *Thermoel.*
- CALCITE.** R. Hare. Proc. Am. Ass. 1882, p. 419. *Crystals with Quarts.*
F. Stenger. Pogg. Ann. xx. p. 304. *Magnetic.*
O. Meyer. N. J. (1), p. 74. *Etching.*
O. Mügge. N. J. (1), pp. 82, 81. "Structure-faces."
A. Cathrein. Zs. K. viii. p. 225. *Predazzo.*
G. Linck. N. J. (1), p. 203. *Artificial Twin-striations.*
F. Pfaff. Ber. Ak. Münch. pp. 63, 380. *Hardness.*
G. v. Rath. Ber. Nied. Ges. Bonn. p. 12. *Cryst.*
A. Stroman. Ber. Oberhess. Ges. xxii. p. 284. *Cryst. Giessen.*
J. O'Reilly. Proc. Dub. Soc. iv. p. 43. *Antrim.*
J. Schramm. Lieb. Ann. cccix. p. 374. *Chem.*
- CARNALLITE.** J. Collins. Min. Mag. v. p. 121. *Cornwall (and assoc. Min.).*
- CASSITERITE.** W. Blake. Am. J. Sc. xxvi. p. 235. *Dakota.*
- CASSITERITE, SPODUMENE, BERYL.** W. Hankel. Abh. Sächs. Ges. p. 23. *Thermoel.*
v. Barytes.
- CELESTINE.** W. Hankel. Abh. Sächs. Ges. p. 575. *Thermoel.*
- CERUSSITE.** P. Groth. Zs. K. vii. p. 475. *Min.*
- CHIOHITE.** W. Eustis. Chem. News, xlviii. p. 109. *Chem.*
- CHRYSOLOLLA.** G. v. Rath. Ber. Nied. Ges. Bonn. pp. 45, 122. *Cryst.*
- CINNABAR.** A. Fichler. Min. Mitth. v. p. 331. *Tyrol.*
- CINNABAR, REALGAR.** M. Boussingault. Ann. Chim. Phys. xxix. p. 363. *Chem.*
Gümbel. Ber. Ak. Münch. p. 111. *Structure.*
- COALS.** G. Starkl. Jahrb. Geol. Reichs. p. 635. *Hütteldorf.*
A. Lasaulx. Zs. K. viii. p. 76. *Laacher See. Twinned.*
P. Groth. Zs. K. vii. p. 594. *Colourless.*
- COPALINE.**
- CORDIERITE.**

- CORUNDUM.** C. Shepard. Am. J. Sc. xxvi. p. 339. *Himalaya*.
- COVELLINE.** M. Webaky. Ber. Ges. Nat. Fr. Berl. p. 99.
- COVELLINE?** A. Griffiths. Chem. News, xlvii. p. 169. *Chem.*
- CRYOLITE.** Cross & Hildebrand. Am. J. Sc. xxvi. p. 271. *Colorado*.
- CRYPHIOLITE.** A. & E. Scacchi. Rendic. Ac. Nap. p. 233. *New Min. Vesuvius*.
- CRYSTALLISATION.** O. Lehmann. Zs. K. viii. pp. 433, 526.
- CRYSTALLOGRAPHY.** A. Schmidt. Zs. K. viii. p. 1. *Contact-Goniometer*.
A. Schrauf. Zs. K. viii. p. 238. *Zone-formula*.
W. Barlow. Nature, xxix. pp. 186, 205. *Symmetry*.
- CRYSTALLOGRAPHY }
(Physical) }** H. Aron. Pogg. xx. p. 272. *Elasticity*.
R. Brauns. N. J. (2), p. 102. *Double Refraction in Cubic Crystals*.
M. Bauer. N. J. Beil. Bd. p. 49. *Refraction (Uniaxial Crystals)*.
E. Mallard. Bull. Soc. Min. p. 45. *Polychroism*.
A. Ben-Saude. Bull. Soc. Min. p. 260. *Double Refr. and Hemihedrim (Cubic Crystals)*.
T. Liebisch. Zs. K. vii. p. 433. *Refraction (Rhombic Crystals)*.
W. Voigt. N. J. (1), p. 21. *Opt*.
A. Schrauf. N. J. (2), p. 82. *Therm*.
E. Lommel. Pogg. xviii. p. 56. "*Isogyrenfläche*,"
K. Koch. Pogg. xviii. p. 325. *Elasticity*.
L. Fletcher. Phil. Mag. xvi. pp. 275, 344, 412. *Therm*.
A. Kundt. Pogg. xx. p. 592. *Elect*.
A. Kundt. Pogg. xx. p. 688. "*Schlierenmethode*," *elect*.
A. Kundt. Ber. Ak. Berl. i. p. 421. *Elect*.
F. Pfaff. Ber. Ak. Münch. pp. 55, 372. *Hardness of Minerals*.
W. Klein. Ber. Nied. Ges. Bonn, p. 210.
v. Quartz.
- CUSPIDINE.** G. v. Rath. Zs. K. viii. p. 38. *Cryst. Vesuvius*; and Ber. Nied. Ges. Bonn, p. 124.
- CUPRODESCLOIZITE.** C. Rammelsberg. Ber. Ak. Berl. (2), p. 1215. *Chem*.
- CYANITE.** O. Korn. Zs. K. vii. p. 595. *Opt*.
v. Gypsum.
- DANBURITE.** C. Hintze. Zs. K. vii. p. 591. *Cryst*.
M. Schuster. Min. Mitth. v. p. 397. *Cryst*.
G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
J. Bachmann. Mitth. Nat. Ges. Bern. p. 2. *Switzerland*.
- DATHOLITE.** T. Liweh. Zs. K. vii. p. 569. *Cryst*.
W. Hankel. Abh. Sächs. Ges. p. 43. *Thermool*.
N. Kokscharow. Bull. Ac. St. Pet. xxviii. p. 15. *Cryst*.
S. Penfield. Am. J. Sc. xxvi. p. 361. *Chem. Mexico*.
- DESCLOIZITE.** L. v. Werveke. N. J. (2), p. 97. *Twinning*.
- DIALLAG & FELSPAR.** G. v. Rath. Zs. K. viii. p. 46. *Cryst*.
G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
- DIOPSIDE.**

- DIOPHASE.** W. Hankel. Pogg. xviii. p. 424. *Thermoel.*; and Abh. Sächs. Ges. p. 565.
- DOLOMITE.** C. Hintze. Zs. K. vii. p. 438.
- EICHWALDITE.** M. Webaky. Ber. Ak. Berl. (2), p. 671. *Cryst.*
- EMPHOLITE.** L. Igelström öfv. Vet. Ak. Förh. 7, p. 97. *New Min.*; and Bull. Soc. Min. p. 40.
- EPIDOTE.** Damour and Descloizeaux. Bull. Soc. Min. p. 23.
- EPISTILBITE.** C. Hintze. Ber. Nied. Ges. Bonn, p. 276. *Cryst.*
- ERYTHRITE.** S. Przybytek. Bull. Ac. St. Pet. xxvii. p. 145. *Oxydation.*
- EUCHROITE.** R. Solly. Camb. Phil. Soc. Proc. p. 406. *Cryst.*
- EUCLASE.** W. Hankel. Pogg. xviii. p. 425. *Thermoel.*; and Abh. Sächs. Ges. p. 576.
- FAHLUNITE.** L. Igelström öfv. Vet. Ak. Förh. 8, p. 91. *Chem. (Persbergite).*
- FELSPAR.** H. Foerstner. Zs. K. viii. p. 125. *Pantelleria.*
A. Damour. Bull. Soc. Min. p. 287. *Rochesauve. Chem.*
F. Fouqué. Bull. Soc. Min. p. 197.
v. Diallage.
- FLUELLITE.** P. Groth. Zs. K. vii. p. 482. *Min.*
- FLUOR.** F. Calker. Zs. K. vii. p. 447. *Etching, &c.*
F. Pfaff. Ber. Ak. Münch. p. 64. *Hardness.*
E. Sarasin. C. R. 97, p. 850. *Opt.*
W. Hankel. Abh. Sächs. Ges. p. 203. *Thermoel.*
- FOWLERITE.** L. Igelström öfv. Vet. Ak. Förh. 7, p. 94. *Chem.*
- FRANKLINITE ORES.** P. Rickets. Trans. New York Ac. ii. p. 26. *Chem.*
- GADOLINITE.** A. Welsbach. Ber. Ak. Wien, p. 332. *Ytterby.*
- GAHNITE.** R. Solly. Camb. Phil. Soc. p. 407. *Cryst.*
- GALENA.** G. Freda. Rendic. Ac. Nap. p. 292. *Chem.*
- GARNET.** C. Klein. N. J. (1), p. 87. *Opt.*
A. Cathrein. Zs. K. viii. p. 224.
G. Kunz. Proc. Am. Ass. p. 269. *Canada.*
L. Igelström, öfv. Vet. Ak. Förh. p. 94. *Chem.*
- GEARKSUTITE.** P. Groth. Zs. K. vii. p. 481. *Min.*
Cross and Hildebrand. Am. J. Sc. xxvi. p. 271. *Colorado.*
- GIBBSITE.** W. Eustis. Chem. News, xlviii. p. 98. *Chem.*
- GILBERTITE.** J. Collins. Min. Mag. v. p. 121. *Cornwall. Chem.*
- GISMONDINE.** A. Descloizeaux. Bull. Soc. Min. p. 301. *Opt.*
- GOLD.** G. Ulrich. N. J. (2), p. 136. *New Zealand.*
V. Ball. Proc. Roy. Dub. Soc. iv. p. 33. *Min.*
G. Kinahan. Proc. Roy. Dub. Soc. iv. p. 39. *Wicklow.*
- GRAPHITE.** M. Boussingault. Ann. Chim. Phys. xxix. p. 363. *Chem.*
- GRODDECKITE.** A. Arzruni. Zs. K. viii. p. 343. *New Min.*
- GYPNUM.** F. Pfaff. Ber. Ak. Münch. pp. 63, 383. *Hardness.*
E. Reusch. Ber. Ak. Berl. (1), p. 259. *Cleavage.*

- GYPSUM, STIBNITE,
BISMUTHITE, ORPI-
MENT, CYANITE } O Mügge. N. J. (2), p. 13. "*Gleitflächen.*"
- HÄRMATITE. A. Schmidt. Zs. K. vij. p. 547. *Cryst.*
G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
A. Griffiths. Chem. News, xlvii. p. 169. *Chem.*
- HAGEMANNITE. P. Groth. Zs. K. vij. p. 480.
- HELVINE. W. Hankel. Pogg. xviii. p. 422. *Thermoel.*; and Abh. Sächs. Ges. p. 551.
R. Haines. Chem. News, xlviii. p. 6. *Chem.*
- HERRENGRUNDITE? A. Weisbach. N. J. (2), p. 119. *Zwickau.*
- HORNBLEND. G. Starkl. Jahrb. Reichs. p. 640. *Christianberg.*
A. Cathrein. Zs. K. viii. p. 221. *Predazzo.*
v. Augite.
- HUMITE. A. Kenngott. N. J. (2), p. 174. *Chem.*
E. Scaocchi. Rendic. Ac. Nap. p. 303. *Cryst.*
G. Freda. Rendic. Ac. Nap. p. 248. *Chem.*
- HYALOPHANE. L. Igelström. Bull. Soc. Min. p. 139. *Jakobsberg.*
- ICE. H. Bischoff. Verh. Nat. Ges. Basel. p. 192. *Cryst.*
- IDOCRASE. G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
- IRON ORES. A. Julien. Trans. New York, Ac. ii. p. 6. *Origin of.*
J. Newberry. Trans. New York, Ac. Sc. ii. p. 13. *Origin of.*
- ITALY. J. Becc and L. Thonard. Rev. Min. xiv. p. 80. *Mineral History.*
- JADE. H. Fischer. N. J. (2), p. 80.
- JADEITE. H. Fischer. N. J. (2), p. 92.
A. Krenner. N. J. (2), p. 173. *Chem.*
- JAMESONITE. O. Luedecke. N. J. (2), p. 116. *Harz.*
- JEREMJEWITE. A. Damour. C. R. 96, p. 675. *New Min.*; and Bull. Soc. Min. p. 20.
M. Websky. Ber. Ak. Berl. (2), p. 671. *Cryst.*
- LAXMANNITE. N. Kokseharow. Bull. Ac. St. Pet. xxviii. pp. 23, 267. *Cryst.*
- LEPIDOLITE. M. Page. Chem. News, xlviii. p. 109. *Chem.*
G. Kunz. Proc. Am. Ass. p. 274. *Maine.*
- LEUCITE. G. Freda. Rendic. Ac. Nap. p. 251. *Metamorphism of.*
G. v. Rath. Ber. Nied. Ges. Bonn, pp. 42, 115. *Cryst.*
- LINARITE. G. Freda. Rendic. Ac. Nap. p. 141. *Vesuvius.*
- LITHIOPHILITE. S. Penfield. Am. J. Sc. xxvi. p. 176. *Chem.*
- MAGNETITE. A. Cathrein. Zs. K. viii. p. 219. *Predazzo.*
- MELLITE. W. Hankel. Abh. Sächs. Ges. p. 553. *Thermoel.*; and Pogg, xviii. p. 422.
- MESOLITE. M. Heddle. Min. Mag. v. p. 115. *Skye.*
- METALLIFEROUS VEINS. J. Leconte. Am. J. Sc. xxvi. p. 1.

- MIARGYRITE.** G. v. Rath. Zs. K. viii. p. 25. *Cryst.*
W. Lewis. Camb. Phil. Soc. Proc. iv. p. 365. *Cryst.*
- MICA.** F. Pfaff. Ber. Ak. Münch. p. 66. *Hardness.*
M. Jaffé. Ber. Oberhess. Ges. xxii. p. 230. *Chem.*
G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
- MILARITE.** W. Hankel. Abh. Sächs. Ges. p. 555. *Thermoel.*; and
Pogg. xviii. p. 423.
- MINNETESITE.** H. Bolton. Chem. News, xlvii. p. 251. *Analysis of.*
v. Lasaulx. Ber. Nied. Ges. Bonn, p. 6. *Spec. Gravity.*
J. Thoulet. C. R. 96, p. 1373. *Elasticity of.*
G. Brush. Proc. Am. Ass. 1882, p. 1. *History of American.*
H. Bolton. Proc. Am. Ass. 1882, p. 271. *Organic Acids on.*
F. Pfaff. Ber. Ak. Münch. pp. 55, 372. *Hardness.*
J. Leconte. Am. J. Sc. xxv. p. 424. *Formation of.*
- MINERAL VEINS.** G. Magel. Ber. Oberhess. Ges. xxii. p. 297. *Cryst. Auerbach.*
- MISPICKEL.** G. Freda. Rendic. Ac. Nap. p. 290. *Chem.*
- MOLYBDENITE.** G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
- MONAZITE.** G. Freda. Rendic. Ac. Nap. p. 250. (*Var.*) *Chem.*
- MONTICELLITE.** W. Brögger. N. J (1), p. 80. *Minerals of.*
- MOSS (loc.)**
- NATROLITE.** W. Hankel. Abh. Sächs. Ges. p. 33. *Thermoel.*
- NEW MINERALS.** Lodin. Bull. Soc. Min. p. 178. (Cu S)₂ + Pb S. *Val Godemas.*
T. Lippit. Chem. News, xlviii. p. 98. *Ferrous Aluminic Sulphate, Mexico.*
- See Belonesia, Bertrandite, Covellite, Cryphiolite, Eichwaldite, Empholite,
Groddeckite, Jeremejewite.
- OILS.** M. Boussingault. Ann. Chim. Phys. xxix. p. 363. *Chem.*
- OLIGOCLASE.** v. Albite.
- OLIVINE.** N. Kokscharow. Bull. Ac. St. Pet. xxviii. p. 275. *Cryst.*
- ORPIMENT.** v. Gypsum.
- ORTHITE.** O. Luedecke. Zs. Naturw. Halle, p. 229.
- ORTHOCLASE.** F. Gonnard. C. R. 96, p. 1370. *Cryst.*; and Bull. Soc. Min.
p. 265.
R. Solly. Camb. Phil. Soc. Proc. p. 406. *Cryst.*
- PACHNOLITE.** N. Kokscharow. Bull. Ac. St. Pet. xxviii. p. 281. *Cryst.*
P. Groth. Zs. K. vii. p. 457. *Min.*
Cross & Hildebrand. Am. J. Sc. xvi. p. 271. *Colorado.*
- PENNINE.** W. Hankel. Abh. Sächs. Ges. p. 561. *Thermoel.*; and
Pogg. xviii. p. 424.
- PERSBERGITE.** v. Fahlnite.
- PHENAKITE.** W. Hankel. Abh. Sächs. Ges. p. 558. *Thermoel.*; and
Pogg. xviii. p. 423.
- PHILLIPSITE.** A. Descloizeaux. Bull. Soc. Min. p. 305. *Opt.*
- PHYLLITE.** A. Fichler. Min. Mitth. v. p. 293.
- PICRANALCIME.** v. Lasaulx. Ber. Nied. Ges. Bonn, p. 170. *Cryst.*

- PITCHBLENDER.** H. v. Foullon. Jahrb. Geol. Reichs. p. 1. *Decomp. Products.*
- PLAGIOCLASE.** G. Starkl. Jahrb. Geol. Reichs. p. 641. *Christianberg.*
- PLAGIONITE.** F. Sandberger. N. J. (2), p. 94. *Arnsberg.*
O. Lüdecke. N. J. (2), p. 112.
- PLINTHITE.** M. Heddle. Min. Mag. v. p. 115. *Skys.*
- PREHNITE.** W. Hankel. Abh. Sächs. Ges. p. 28.
- PROSOPITE.** P. Groth. Zs. K. vii. p. 487.
Cross & Hildebrand. Am. J. Sc. xxvi. p. 271. *Colorado.*
- PYKNOPHYLLITE.** G. Starkl. Jahrb. Geol. Reichs. p. 644. *Aspang.*
- PYRRHOTITE.** G. Freda. Rendic. Ac. Nap. p. 294. *Chem.*
- PYRITES.** G. Freda. Rendic. Ac. Nap. p. 294. *Chem.*
v. Lasaulx. Ber. Nied. Ges. Bonn, p. 75. *Cryst.*
- PYROMORPHITE.** W. Hankel. Abh. Sächs. Ges. p. 554. *Thermoel.*; and Pogg. xviii. p. 423.
- PYROXENE.** G. Freda. Rendic. Ac. Nap. p. 249. *Cupriferosus.*
- QUARTZ.** W. Hankel. Abh. Sächs. Ges. p. 457. *Thermoel.*; and Ber. Sächs. Ges. p. 35; and Pogg. xix. p. 818.
W. Röntgen. Pogg. xviii. pp. 213, 584. *Elect. and Opt.*
Pogg. xix. pp. 319, 518. *Elect. and Opt.*
Ber. Oberhess. Ges. xxii. pp. 49, 98, 181. *Elect. and Opt.*
A. Kundt. Pogg. xviii. p. 228. *Elect. and Opt.*
F. Pfaff. Ber. Ak. Münch. p. 66. *Hardness.*
M. Websky. Ber. Ges. Nat. Fr. Berl. p. 127. *Enclosures.*
C. Friedel and J. Curie. C. R. 96, pp. 1262, 1389. *Tyroel.*
H. Lewis. Proc. Ac. Phil. p. 49. *Enclosure.*
H. Dufet. C. R. 96, p. 1221. *Opt.*
B. Hare. Proc. Am. Ass. 1882, p. 419. *Crystals with Calcite.*
J. Bachmann. Mitth. Nat. Ges. Bern. p. 4. *Cryst.*
- RALSTONITE.** P. Groth. Zs. K. vii. p. 471. *Min.*
- REALGAR.** v. Cinnabar.
- RESINS.** M. Boussingault. Ann. Chim. Phys. xxix. p. 363. *Chem.*
- RHADOPHANE.** v. Scovillite.
- RHODONITE.** W. Rice. Science, i. p. 601. *Connecticut.*
L. Igelström. öfv. Vet. Ak. Förh. 7, p. 93. *Chem.*
J. Collins. Min. Mag. v. p. 211. *Minerals of.*
- RIO TINTO.** M. Hollrung. Min. Mitth. v. p. 304.
- RUBELLANE.** A. Arzruni. Zs. K. viii. p. 330.
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 Pogg, xviii. p. 425.
 SPODUMENE. v. Cassiterite.
 STREATITE. J. Dobbie. Min. Mag. v. p. 131. *Chem. Glasgow.*
 STIBNITE. E. Dana. Am. J. Sc. xxvi. p. 214. *Cryst. Japan.*
 v. Gypsum.
 STONEHAM (MAINE). G. Kunz. Proc. Am. Ass. p. 271. *Minerals of.*
 STREONTIANITE. W. Hankel. Abh. Sächs. Ges. p. 570. *Thermoel.*; and
 Pogg. xviii. p. 425.
 SULPHUR. E. Divers and T. Shimidzu. Chem. News, xlviii. p. 284.
Chem. Japan.
 v. Lasaulx. Ber. Nied. Ges. Bonn, p. 9. *Enclosures.*
 A. Arzruni. Zs. K. viii. p. 338.
 SUTHERLAND. M. Heddle. Min. Mag. v. pp. 133, 217. *Minerals of.*
 SYLVINE. K. Koch. Pogg. xviii. p. 325. *Elasticity.*
 J. Schramm. Lieb. Ann. ccix. p. 374. *Chem.*
 TALC. F. Pfaff. Ber. Ak. Münch. p. 62. *Hardness.*
 TEPHROITE. H. Sjögren. Zs. K. viii. p. 241.
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 BLENDE. }
 THOMSENOLITE. P. Groth. Zs. K. vii. p. 465.
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 TOPAZ. G. Kunz. Proc. Am. Ass. p. 271. *Stoneham.*
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 TURQUOISE. W. Blake. Am. J. Sc. xxv. p. 197. *Arizona.*
 ULLMANNITE. C. Klein and P. Jannasch. N. J. (1), p. 180.
 VAUQUELINITE. N. Kokscharow. Bull. Ac. St. Pet. xxviii. pp. 23, 267
Cryst.
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 VESUVIUS. P. Franco. Rendic. Ac. Nap. p. 1 (*Mte. Somma*). *Minerals of.*
 WERMLAND. L. Igelström. öfv. Vet. Ak. Förh. 7, p. 91.
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 A. Lacroix. Bull. Soc. Min. p. 80. *Beaujolais.*
 XENOTIME. G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.

LIST OF ABBREVIATIONS USED IN INDEX.

ABH. AK. BERL.	K. Akademie der Wissenschaften. Abhandlungen. Berlin.
ABH. AK. MÜNCH.	Abhandlungen der math-phys. Classe der k. bayerischen Akademie der Wissenschaften. München.
ABH. SÄCHS. GES.	Abhandlungen der math-phys. Classe der k. sächsischen. Gesellschaft der Wissenschaften zu Leipzig.
AM. J. SC.	The American Journal of Science and Arts. Newhaven.
AM. NAT.	American Naturalist. Philadelphia.
ANN. CHIM. PHYS.	Annales de Chimie et de Physique. Paris.
ANN. MIN.	Annales des Mines, &c. Paris.
ANN. NEW YORK AC.	Annales of the New York Academy of Sciences. New York.
ATT. AC. NAP.	Atti dell' Accademia Pontaniana. Napoli.
ATT. IST. NAP.	Atti del Reale Istituto d' Incoraggiamento. Napoli.
BER. AK. BERL.	K. Akademie der Wissenschaften. Sitzungsberichte. Berlin.
BER. AK. MÜNCH.	Sitzungsberichte der math-phys. Classe der k. Akademie der Wissenschaften zu München.
BER. AK. WIEN.	Sitzungsberichte der k. Akademie der Wissenschaften. Wien.
BER. GES. NAT. FB. BERL.	{ Sitzungsberichte der Gesellschaft naturforschender Freunde zu Berlin.
BER. NIED. GES. BONN.	Sitzungsberichte der nieder-rheinischen Gesellschaft für Natur-und Heilkunde. Bonn.
BER. OBERHESS. GES.	Bericht der oberhessischen Gesellschaft für Natur-und Heilkunde. Giessen.
BER. SÄCHS. GES.	Berichte über die Verhandlungen der k. sächsischen Gesellschaft der Wissenschaften zu Leipzig.
BER. SENCK. GES.	Berichte über die Senckenbergische naturforschende Gesellschaft. Frankfurt-a-M.
B. H. ZTG.	Berg-und Hüttenmännische Zeitung. Leipzig.
BIH. VET. AK. HAND.	Bihang till k. Svenska Vetenskaps-Akademiens Handlingar. Stockholm.
BULL. AC. ST. PET.	Bulletin Académie Impériale des Sciences de St. Petersbourg.
BULL. SOC. MIN.	Bulletin de la Société Minéralogique de France. Paris.
CAMB. PHIL. SOC.	Cambridge Philosophical Society. (Transactions and Proceedings.) Cambridge.
CAN. NAT.	Canadian Naturalist, &c. Montreal.
CHEM. CENT. BL.	Chemisches Central-Blatt. Hamburg und Leipzig.
CHEM. NEWS.	Chemical News, &c. London.
C. R.	Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Paris.

FORH. VID. SELS. CHRIST. Forhandlingar i Videnskabs-Selskabet i Christiania.

- JAHRB. GEOL. REICHS.** Jahrbuch der k.k. geologischen Reichsanstalt. Wien.
JAHRB. L. MUS. KÄRNT. Jahrbuch des naturhistorischen Landes-Museums von Kärnten. Klagenfurt.
J. AS. SOC. BENG. Journal of the Asiatic Society of Bengal. Calcutta.
J. PRAKT. CHEM. Journal für praktische Chemie. Leipzig.

LIEB. ANN. Liebigs Annalen der Chemie. Leipzig und Heidelberg.

MÉM. AC. SC. Mémoires de l'Académie des Sciences de l'Institut de France. Paris.
MEM. IST. LOMB. Memorie del reale Istituto Lombardo, &c. Milano.
MÉM. PRÉS. AC. SC. Mémoires présentés à l'Académie des Sciences de l'Institut de France. Paris.

MIN. MITTH. Mineralogische und petrographische Mittheilungen. Wien.
MITTH. GEOL. GES. WIEN. { Mittheilungen der k.k. geographischen Gesellschaft. Wien.
MITTH. NAT. GES. BERN. { Mittheilungen der naturforschenden Gesellschaft. Bern.

N. CEM. Il Nuovo Cimento. Pisa.
N. J. Neues Jahrbuch für Mineralogie, Geologie, und Palaeontologie.

OFV. VET. AK, FÖRH. Ofversigt af Kongliga Vetenskaps-Akademiens Forhandlingar. Stockholm.
OY. DANSK. SELS. FÖRH. Oversigt over det k. danske videnskabernes Selskabs Forhandlingar. Copenhagen.

PHIL. MAG. London, Edinburgh and Dublin Philosophical Magazine, &c. London.
POGG. Annalen der Physik und Chemie. Leipzig.
PROC. AC. PHIL. Proceedings of the Academy of Natural Sciences. Philadelphia.
PROC. AM. ASS. Proceedings of the American Association for the Advancement of Science. Salem.
PROC. BOS. SOC. Proceedings of the Boston Society of Natural History. Boston.
PROC. ROY. DUB. SOC. Scientific Proceedings of the Royal Dublin Society. Dublin.

RENDIC. AC. NAP. Rendiconto dell' Accademia delle Scienze Fis. e. Math. Napoli.
REV. D. MIN. Revue Universelle des Mines, &c. Paris et Liège.

SCHR. NAT. VER. SCHLES.-HOLS. { Schriften des naturwissenschaftlichen Vereins für Schleswig-Holstein. Kiel.
SCIENCE. Science. Cambridge, Mass.

TRANS. ALB. INST. Transactions of the Albany Institute. Albany, U.S.

TRANS. NEW YORK AC. Transactions of the New York Academy of Sciences. New York.

VERH. NAT. GES. BASEL. Verhandlungen der naturforschenden Gesellschaft. Basel.
 VERH. NAT. VER. } Verhandlungen des naturhistorischen Vereins der Preussischen Rheinlande und Westphalens. Bonn.
 RHEINL. }
 VET. AK. HAND. Svenska Vetenskaps-Akademiens Handlingar. Stockholm.

Zs. K. Zeitschrift für Krystallographie und Mineralogie. Leipzig.
 Zs. NATURW. HALLE. Zeitschrift für Naturwissenschaften. Halle.

Beil. Bd. Beilage Band.
 Corr. Bl. Correspondenz Blatt.

<i>Assoc.</i>	Associated.
<i>Chem.</i>	Chemical.
<i>Cryst.</i>	Crystallographical.
<i>Elect.</i>	Electric.
<i>Loc.</i>	Local or Locality.
<i>Min.</i>	Mineral or Mineralogical.
<i>New Min.</i>	New Mineral.
<i>Opt.</i>	Optical.
<i>Pyroel.</i>	Pyro-electric.
<i>Thermoel.</i>	Thermo-electric.
<i>Therm.</i>	Thermic.
<i>Var.</i>	Variety

Abstracts and Notes.

THE *Variolite of Jalguba, Government of Olonetz, Russia.* Lawinsson-Lessing, of St. Petersburg, has microscopically and chemically examined (*Min. Mitth.* B. VI. s. 281, 1885) the variolite found *in situ* near Jalguba Bay, Lake Onega. Prof. Inostranzeff had already compared sections of this rock with the variolite pebbles of the river Durance, France, in 1874. At Jalguba, it occurs associated with diabasic (doleritic) rocks, varying in texture from that of a typical diabase to aphanitic and porphyritic varieties. Gabbro, or euphotide, which are its usual associates, according to the French geologists, are not found here, but the variolite is surrounded or encircled on all sides by the diabase. From the microscopical investigation, the author recognises four types which are characterised by differences in structure and colour. These types are as follows:—

Type I.—The variolæ and groundmass are similarly coloured and of similar structure (excepting the radial structure of the variolæ). The former contain much glass, the radii are feebly developed, and sometimes pass insensibly into the groundmass.

Type II.—Has a structure similar to that of type I., but the colour of the variolæ is of a clear brown, while that of the groundmass is green.

Type III.—The variolæ are entirely crystalline, and are separated from the groundmass by a dark periphery, forming the typical variolite. Colour similar to type II.

Type IV.—Structure and colour entirely differing from the preceding types; the variolæ are of a grayish-brown, and the groundmass green.

In types III. and IV. the groundmass is peculiar, from the abundance of devitrification products; and there are intermediate varieties. The author gives the name variolite-aphanite to one form of this rock which is very abundant at Jalguba. Under the microscope, a system of felspar radii obscured with numerous augite crystals is seen to pervade a clear brown glassy groundmass. This system is resolved into individual radial fibrous groups (tufts) resembling variolæ, but which are anastomosed together, leaving only a slight amount of interstitial glass. This seems to constitute an intermediate stage between diabase and typical variolite. Its characteristics are—a clear brown glassy groundmass, enclosing brown grains, strands, and other devitrification products, felspar radii, augite,

and magnetite. Detailed descriptions of the microscopical characters of the varieties of this variolite are given, and also analyses showing its relation to the diabase. Separate analyses also are given of the variolæ and of the groundmass, confirming the results already arrived at by Delesse, Michel-Lévy, and Von Gümbel, that the former are richer in silica and poorer in alumina and magnesia than the latter.

The author sums up as follows :—

1. At Jalguba, the variolite-aphanite and the typical variolite must be differentiated.

2. The typical variolite falls into two principal groups : (a) variolite with the variolæ and groundmass of the same colour, and (b) having the variolæ and groundmass of different colours. Each of these groups contains (a) having much glass, with variolæ only distinguished from the groundmass by the felspar radii, and (b) having a complicated groundmass and completely crystalline variolæ.

3. The principal constituents of these rocks are plagioclase, augite (and a glassy felspar-paste); those accessory are chlorite, epidote, magnetite, with quartz and calcite as fissure-filling minerals.

4. The most important structure is that of the felspar rays of the variolæ.

5. The different chemical constitution of the variolæ and of the groundmass is due to the predominance of the felspar in the first, and the pyroxene in the last.

6. The variolites must be grouped with the diabases.

7. The variolite structure is not the result of special chemical combination, but is due to an unknown exterior cause, "contraction through sudden cooling?" (*Erstarrungsgeschwindigkeit?*)

8. The variolite of Jalguba resembles in variety of texture, &c. all those hitherto known.

T. D.

G. vom RATH. *Mineralogische Notizen* (*Verh. des Naturh. Vereins d. preuss. Rheinl. u. Westf.* 1884, p. 290).

These notices contain the following four papers :—

1. *On Quartz from North Carolina.* The crystals occur with finely crystallised examples of other minerals in druses or "pockets" from the localities which have furnished emeralds and the beautiful variety of Spodumene known as Hiddenite. They resemble in appearance the peculiar quartz from Zöptau, in Moravia, described by Prof. vom Rath in

Zeitschrift für Krystallographie, Vol. V., but are characterised by the frequent occurrence of well-developed faces of the forms $3R\{7\bar{2}2\}$ and $-\frac{3}{2}P\frac{3}{2}\{21\bar{1}\}$.

The new forms observed are—

- $-\frac{1}{2}P\frac{1}{2}\{17\ 1\ \bar{2}\}$
- $-\frac{1}{4}P\frac{1}{4}\{116\ 53\ 10\bar{6}\} = -\frac{1}{2}P\frac{1}{2}\{11\ 5\ 10\}\ (?)$
- $-\frac{1}{2}R\{44\bar{1}\}$
- $-\frac{3}{2}P\frac{3}{2}\{81\bar{2}\}$

The crystals are frequently compound, consisting as usual of two individuals interpenetrating in inverse positions; this twin structure is traced in the paper with considerable detail; on one such crystal the rhombohedron face $3R\{7\bar{2}2\}$ is replaced by $-2R\{11\bar{1}\}$ and $-8R\{8\bar{8}5\}$ instead of by $-3R\{44\bar{5}\}$ as is usually the case, and it is singular that G. Rose found a similar peculiarity in Swiss twins in which the same face $3R$ is replaced by $-\frac{1}{2}R\{88\bar{4}\}$.

Among many others, two crystals of particularly curious appearance are described; one closely resembling calcite in habit, a combination of the forms $\infty R\{2\bar{1}1\}$, $R\{100\}$, $-\frac{1}{2}R\{441\}$, $-\frac{1}{2}R\{110\}$, $-R\{22\bar{1}\}$, capping an ordinary crystal of quartz; the other characterised by a remarkable development of the faces $2P2\{41\bar{2}\}$, $-3P\frac{3}{2}\{52\bar{4}\}$, $-\frac{1}{2}P\frac{1}{2}\{16\ 7\ 1\bar{4}\}$, $-\frac{1}{2}P\frac{1}{2}\{17\ 8\ 1\bar{6}\}$, $-4P\frac{1}{4}\{2\bar{1}2\}$, $-\frac{3}{2}P\frac{3}{2}\{18\ 7\ 1\bar{4}\}$, $-6P\frac{3}{2}\{8\ 5\ 10\}$ whose edges are parallel to an edge of the common quartz pyramid.

2. *On a Crystal of Stephanite from Mexico* of very unusual appearance and distinguished by the large development of the new pyramid $\frac{1}{2}P\frac{1}{2}\{11\ 3\ 6\}$.

3. *On Tridymite from Krakatoa*. The Tridymite occurs in the lava of Long Island, and is found in measurable crystals, a very rare mode of occurrence. It is mostly in simple hexagonal tables, but partly also in the usual twinned groups. One of these was found to be twinned by two distinct laws, the outer pairs of four consecutive leaflets consisting each of two crystals twinned on a face $\frac{1}{2}P\{855\}$ (referred to the hexagonal system), while the two outer leaflets are twinned on a face of $\frac{1}{2}P\{10\ 1\ 1\}$. This has also been found to be the case with crystals from Pachuca; and in fact the Tridymite from Krakatoa closely resembles in every respect that from other localities.

4. *On Colemanite from California*, by Dr. C. BODEWIG and G. vom RATH. Colemanite is a calcium borate from Death Valley, Inyo Co., which has the formula $Ca_2 B_6 O_{11} + 5 H_2 O$, and is therefore very near to Pandermite or Priceite ($Ca_2 B_6 O_{11} + 3 H_2 O$) in composition.

The crystals resemble datholite in appearance. Hardness between that of fluor and apatite. Sp. gr. = 2.417.

System oblique— $a : b : c = 0.7769 : 1 : 0.5416$.

$\beta = 69^{\circ}43\frac{1}{4}'$.

Cleavage parallel to the plane of symmetry. Fourteen forms were observed in combination.

Plane of the optic axes for sodium light perpendicular to the plane of symmetry, and inclined at an angle of $82^{\circ}42'$ to the vertical axis c in the obtuse angle between the axes a and c . True axial angle = $55^{\circ}20'$, mean index of refraction = 1.590.

These results are confirmed by the observations of Professors Hiortdahl and Wendell Jackson, who have at the same time and independently studied the new mineral.

It may be added that the first of the above four papers contains some interesting notes upon the fine private collection of Mr. C. Bement, in Philadelphia.

H. BARON V. FOULLON (*Jahrb. d. k. k. geol. Reichsanstalt*, 1884, p. 367) has examined the crystalline form of Tin. This was found by Miller to be tetragonal, but a rhombic variety has also been described by Trechmann (in vol. iii. of this Magazine). The crystals of Tin carefully described in the Paper were obtained from the molten metal, and agree in form with those described by Miller; the latter were obtained by galvanic deposition; it seems, therefore, that the tetragonal crystals may be obtained both by reduction from solutions and also by direct crystallisation from the molten metal. They are generally twinned, with frequent repetition on the face P (111).

It is concluded finally that the following are the modifications in which Tin is known to occur:—

- (1) Grey Tin, Sp. gr. 5.781 — 5.809.
- (2) Rhombic Tin, Sp. gr. 6.52 — 6.56.
- (8) Tetragonal Tin, Sp. gr. 7.196 (perhaps higher).
- (4) Previously Molten Tin (doubtful), Sp. gr. 7.2795.

The last has been distinguished as a variety by Rammelsberg.

H. A. M.

O. MÜGGE, in the first number of the new *Jahrbuch der Hamburgischen wissenschaftlichen Anstalten* (Hamburg, 1884, p. 67), from a microscopical examination of sections of Cryolite with polarised light, concludes

that this mineral (which is actually oblique, though geometrically very near to the Rhombic or even the Cubic System) is twinned not only upon the planes OP (001), $\infty P \infty$ (100), ∞P (110), as stated by Websky and Dana, but also, according to a fourth twin law, with the twin-plane $\pm \frac{1}{2} P$ (112, 11 $\bar{2}$).

The conclusion is derived from a study of the lamellæ, striations, and lines of extinction on sections of Greenland Cryolite cut parallel to the cleavage planes. The author also finds that fragments which show no indication of the newly-described twin structure may have it permanently developed after they have been raised to the melting temperature of Zinc (428° C), and he suggests that this may account for the fact that the upper layers of the mineral, which have been exposed to the heat of lava flows, are cloudy, while the lower layers are generally clear. H. A. M.

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On the Physical and Geometrical Properties of Graphite.

By HJ. SJÖGREN. Communicated by H. Müller, Ph.D., F.R.S.

[Read March 10th, 1885.]

E. D. CLARKE was the first mineralogist by whom crystallised graphite was observed and examined. As early as 1821,* he described some graphite crystals from the mines at Borrowdale, in Cumberland. Clarke designated graphite by the name of "carburet of iron" or "plumbago," and stated its form to be that of an oblique four sided prism, the obtuse angle of which was found by measurement with the contact goniometer ("the common goniometer") to be 118° .

Since then crystallised graphite has been examined by several mineralogists. Haidinger† and Kenngott‡ have pronounced the system of axes to be hexagonal, but Nordenskiöld,§ who has made the most complete research, is of Clarke's opinion, that the system of crystallisation is monoclinic. The determinations of Nordenskiöld have been most generally accepted, and quoted in most manuals. In the present paper the twins of

* *Annals of Philosophy*, New Series, vol. ii. p. 417.

† *Handbuch der bestimmenden Mineralogie*, p. 513, 1845.

‡ *Sitzungsber. d. math. naturw. Classe der Wiener-Akad.* vol. xiii. p. 469, 1854.

§ *Pogg. Ann.* vol. xcvi. p. 110, 1855.

graphite, its gliding-faces "*Gleitfläche*," its percussion-figures, the nature of its etching-figures, and its relative conduction of heat in different directions will be described. The numerical values of the angle measurements made by me have been left out of this brief paper, as they have not led to any unequivocal result; with regard to several other points, the reader is referred to my more detailed account in "*Ofversigt af Kongl. Svenska vetenskaps akademiens förhandlingar*," p. 29, 1884. The material that I have made use of consists of natural crystals from Ceylon, and from Pargas in Finland, and artificial graphite from some furnaces in Wermland.

Angle Measurements.

In computing the angle measurements carried out on six crystals, the most importance is attached to those angles which are situate in the plane of the cleavage surface, *i.e.* the so-called horizontal angles. If the system of crystallisation be hexagonal, the values 60° and 120° must be met with among these angles. The computations showed that the angles in question always deviated somewhat from the above values, and that the variations amounted to above 2° towards each side.

In order to check these results, direct measurements were executed of those plane angles which are formed on the basal plane by the striæ running in three directions, and forming triangles on the cleavage surface. Those angles were measured under a microscope provided with a capillary cross and movable stage.

The measurements could be performed with great accuracy, and the degree of accuracy was checked by means of measuring the three angles of the same triangle. It appeared from measurements executed on five crystals, that the angles varied quite irregularly from $61^\circ 40'$ to $57^\circ 16'$. If the largest, mean, and smallest angles of the same triangle are denoted respectively by α , β , and γ , we find the values of α to vary from $61^\circ 40'$ to $60^\circ 6'$; those of β from $61^\circ 24'$ to $59^\circ 18'$; and those of γ from $59^\circ 53'$ to $57^\circ 16'$. Sometimes *two* angles of the same triangle are above 60° , and the third below; sometimes only *one* angle is larger and both the others smaller than 60° .

The variation in each of the angles α , β , and γ , is considerably greater than can be explained by errors of measurement, for while the errors of the sum $\alpha + \beta + \gamma$ do not exceed $0^\circ 16'$, the variations in α are $1^\circ 34'$, in β $2^\circ 6'$, and in γ $2^\circ 37'$.

From these facts it seems quite evident that the angles between the three crystallographic directions represented by the systems of striæ are not constant, but subject to considerable variations. It is thus easy to

understand why other angles also manifest an equal want of constancy. This variableness of the plane angles as well as of solid angles agrees with the results of previous investigations of graphite. For neither can the measurements obtained by different authors, as Kenngott, Haidinger, and Nordenskiöld, be brought into accordance with one another, nor even the angles measured by Nordenskiöld on different crystals be reduced to the same system of axes.*

The three angles of the basal plane varying irregularly from 60° , the crystallographic development evidently presents no obstacle to the mineral being regarded as hexagonal. But in order to arrive at a surer determination of the system of crystallisation, the physical properties of the mineral must be inquired into, and after having described its twins we shall pass over to that part of the subject.

Twins.

Although the striæ of the basal plane have been mentioned by all authors who have occupied themselves with this mineral, no one has investigated their nature. I have found them to consist of ridge-like elevations. These ridges are enclosed either by three planes, two of which form the sides of the ridge, and the third, parallel to the basal plane of the principal crystal, truncates the edge of the ridge; or else by only two planes that intersect at the edge of the ridge.

On cleaving the crystal scales, the ridges are found not to lie above the basal plane, but each ridge goes down into the crystal itself (figs. 1 and 2).



FIG. 1.



FIG. 2.

The cleavages of the ridge are parallel to its sides, and form obtuse angles with the corresponding cleavages of the crystal scale.

It is easy to measure the re-entering angle A between the sides of the ridge and the basal plane.

The mean value of a great number of measurements of crystals from Pargas and Ceylon is—

$$A = 159^\circ 32'$$

The plane bisecting this angle is a plane of symmetry with regard to both the elements of the crystal, and accordingly a twinning-plane. Its inclination B to the basal plane is—

$$B = \frac{360^\circ - A}{2} = 100^\circ 14'$$

* *Pögg. Ann.* vol. xcvi, p. 110, 1855.

Being a twinning-plane this plane must be a real or potential crystal surface; it is, in fact, a real crystal plane occurring in crystals both from Pargas and Ceylon.

On examining the ridges more closely, they are in general found to be constructed of three differently arranged crystal elements, two of these forming the sides of the ridge, and the third its edge (fig. 4). Other ridges consist of only two elements (fig. 3). The middle element 1 *b*, imbedded between the lateral elements, is situated parallel to the crystal 1 *a*, and ought accordingly to be regarded as forming part of this. It is

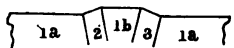


FIG. 4.



FIG. 3.

evident that the elements 1 *b* and 2 have the same position with regard to each other as 1 *a* and 2, and that in both cases the same plane, the pyramid plane *P*, is a twinning-face. Of course, there is the same twinning law also between the elements 1 *b* and 3, and 1 *a* and 3. On the contrary, the twinning law between the elements 2 and 3, which are symmetrically situated with regard to a vertical plane, is a different one. This plane, which is thus also a composition face, is a pyramid surface $\frac{1}{2} P$, the vertical axis of which is half as long as that of the other composition face.

Thus the ridges are constructed of two differently arranged crystal elements, without counting the principal scale itself. Within every ridge twinning has taken place according to two different laws.

It is not without interest to consider how these twins are to be regarded, according as the graphite is supposed to crystallise in the hexagonal, rhombic, monoclinic, or triclinic system. While the three directions of the ridges are equal, if we suppose the system of crystallisation to be hexagonal, it is seen by a simple deduction that with the other systems two or even all the three directions become unequal in value. With those systems of crystallisation which are less symmetrical the twins accordingly become more complicated. If the crystal form is supposed to be hexagonal, the crystal-complex is constructed according to two twinning laws; if it is supposed to be rhombic, according to four; if it is supposed to be monoclinic, according to six or nine different laws, according as the cleavage is supposed to be parallel or at right angles to the plane of symmetry; and lastly, if the crystal form is supposed to be triclinic, nine different twinning laws must also exist.

Gliding-faces and Artificial Twins.

In many minerals with very distinct cleavages in one or more directions,

i.e. with very different degrees of cohesion in different directions, there occur gliding-faces. Such are known to exist in mica, calcite, soda-nitre, cyanite, galena, gypsum, stibnite, bismuthite, and orpiment. The graphite, which has such a distinct cleavage, is also found, in analogy with the above-mentioned minerals, to possess this kind of structural faces. The existence of gliding-faces is proved by bending crystal scales cautiously, as ridge-like striæ then appear strictly analogous to the natural ridges produced by twinning.

Thus, by means of the gliding-faces, it becomes possible to produce artificial twin crystals of graphite, just as artificial crystal twins of calcite may be produced, which have $-\frac{1}{2}R$ for their twinning-face.

We have designated P and $\frac{1}{2}P$, the faces occurring in the ridges, as twinning-faces, and it has been shown that the same symbols are those of the gliding-faces.

On bending a crystal scale the ridges are formed on the concave side and spring out in three directions, which, as we have seen before, make angles of about 60° with one another. The stronger the bending is, the higher and more numerous they become. It is clear that the line $a b c d e$ is equal in length to the line $a' b' c' d' e'$ (fig. 5). If the crystal scale is bent back so as to become plane, or so as to make that surface convex which was before concave, the ridges partly maintain themselves, and new ones arise on the other side that was concave before, but is now plane or convex. This proves that there is a degree of stability in the new state of equilibrium of the molecules comparable to the stability of the molecules in their normal state. Thus by repeatedly bending the crystal scale in both directions ridge-like elevations are produced on both sides of it (fig. 6).

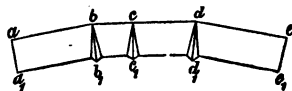


FIG. 5.

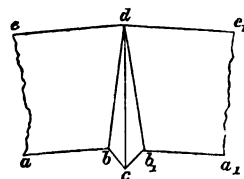


FIG. 6.

If such a scale is pressed between paper, the ridges recede and vanish completely, a gliding or turning of the molecules taking place in the opposite direction, so that they resume their normal position. If the scale is bent, the ridges come forth again in the same places as before.

Percussion-figures.

The percussion-figures exhibited by the graphite after suitably arranged experiments are closely connected with the gliding-faces and the twinning. Such figures are very easily produced on natural crystal scales

as well as on artificial graphite. According to the nature of the material the conditions of the experiments must be somewhat varied, for instance the firmness of the substratum, the sharpness of the point, &c.

If such a scale is chosen for the experiment as is free, as much as possible, from the ridge-like striæ, such striæ will generally be found after the experiment, radiating from the hole into which the point has penetrated. The percussion-figure consists of these striæ that run out in three directions, forming a percussion star with six or three rays (fig. 7). The percussion-figures produced are in general not very regular; the directions of the ridges are certainly always constant,

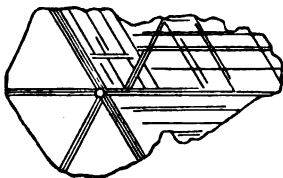


FIG. 7.

but the ridges are not equal in size. On the contrary, in the same star they present many variations with respect to the height, breadth, and length of the rays. In numerous experiments these variations have been found to be altogether irregular, so that there is no reason to suppose that the unequal ridges denote crystallographic directions of different values.

If the crystal scales are thin and firm, for instance in furnace graphite or Cingalese graphite, it is advantageous to employ a hard substratum, such as glass. One then gets small, fine, and regular stars, which are best seen in a microscope, magnified about 70 diameters. If the scales are thicker and softer, for instance in Pargas graphite, no percussion-figures are effected with a glass substratum, but only round holes. In this case softer substrata, wood or paste-board, are used with advantage; by that means percussion-figures are obtained that are large, coarse, and irregular, and best to be seen with the naked eye or with a lens.

The percussion-figures of graphite are of quite a different nature for instance to those of the micas. In the last named mineral a rupture takes place, so that the connection between the molecules in certain directions is broken. In graphite no rupture is ever to be perceived, but only a dislocation. The percussion-figures of this mineral may be altogether referred to the gliding-faces mentioned above. While the percussion-figure of the micas shows in what direction the cohesion is at its minimum with regard to a certain kind of action, the corresponding figure in graphite shows in what direction the resistance against gliding is at its minimum with regard to the same kind of action.

Cohesion.

The cohesiveness of graphite and the cleavages dependent thereon

differ very much in different varieties. In furnace-graphite the cleavage parallel to the basal plane is much less distinct than that in the natural varieties.

The statements in different manuals of mineralogy as to the other cleavages do not at all accord with one another. Tschermak and Naumann-Zirkel mention prismatic cleavages besides the basal. Descloizeaux, on the contrary, records cleavages parallel to Kenngott's fundamental rhombohedron, while Dana does not mention any other cleavage than the basal one.

An examination of Cingalese graphite has proved it to possess no other cleavage than the basal one; on crystal scales being torn asunder by forces parallel to the basal plane, the rupture takes place either quite irregularly or else along gliding-faces and twinning-planes. Pargas graphite agrees with it in this respect.

Combustion and Etching Figures.

The etching-figures of graphite have a very great interest, because they supply us with a better guidance than any other properties of the mineral in determining the system of crystallisation.

In order to produce etching-figures in graphite, the mineral may either be heated in a current of dry oxygen or treated with a mixture of potassium-chromate and sulphuric-acid. By both methods the same sort of etching-figures are obtained.

Graphite is burnt with difficulty; even in a finely disintegrated state it burns with more difficulty than diamond. It being necessary to employ whole crystal scales in order to obtain combustion-figures, the resistance to combination is still more considerable, and one is obliged to use strong heating and much oxygen. It is on furnace-graphite that combustion-figures are most easily produced.

By suitably arranged experiments, small but sharp and distinct etching-figures with marked symmetry are obtained. If the temperature is too high, or the heating is continued too long, the etching-figures become large, their limits uneven, and their shape approaches more and more that of a circle. A crystal scale that has been exposed to such action is lacerated and torn at its edges and perforated in many places by holes 0.1—0.8 mm. in diameter, which are generally round, but sometimes show a tendency to the hexagonal form.

In a great number of experiments the most beautiful combustion-figures were obtained on artificial graphite that was etched in a current of oxygen during one minute.

On being examined with a microscope the combustion-figures were found to occur rather sparsely, and to be small but sharp and distinct. They were extremely regular hexagons 0.003—0.105 mm. in diameter. If the same sort of graphite was etched during $2\frac{1}{2}$ minutes in a current of oxygen, it was covered with numerous combustion-figures, partly larger and expanded, partly smaller and deeper. Their form was generally round, or irregular with notched edges. In some places the figures joined

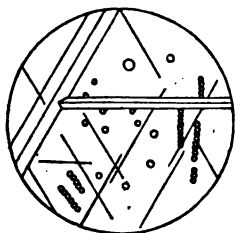


FIG. 8.

into parallel rows, that were at right angles to one of the directions of the striæ. In other places the preparation was perforated; the holes were hexagonal. There were also found on the same preparation very fine etching-figures, visible only when highly magnified; these formed extremely regular hexagons 0.012—0.015 mm. in diameter, with only slightly rounded corners. The sides of the hexagons coincide with the three directions of the striæ (fig. 8).

The same result was obtained on the natural graphite from Pargas and Ceylon.

If the etching is effected by means of a mixture of potassium-chromate and sulphuric-acid the figures always become hexagonal, unless the attack is so violent that they become round or quite irregular.

The nature of the combustion-figures and etching-figures of graphite affords a strong reason to regard the mineral as hexagonal, because, as far as we know at present, the symmetrical properties of the etching-figures are very intimately allied with the system of crystallisation.

It is interesting to compare graphite in this respect with a group of minerals that is closely related to it in external and even some physical properties, viz. the micas. They agree with graphite in the distinct basal cleavage and the pseudo-hexagonal habit shown by their crystals, but, inasmuch as they belong with certainty to the monoclinic system, they differ from it by giving on the basal cleavage etching-figures the symmetry of which is in general *not* hexagonal.

Conduction of Heat.

In order to ascertain the system of crystallisation in another way, the melting-curve of the basal plane was examined.

Senarmont's method, as it has been modified by V. von Lang, was employed, as well as that indicated by Röntgen. The former method seems to be more convenient for graphite, as it allows one to make the

diameter of the curve larger. The curve was regular and sharp until it reached a size of about 4.5 mm.; larger curves showed great irregularities, on account of the wax being liable to melt at the same time over the whole crystal after the curve had attained that size.

The melting-figures obtained appeared to the naked eye as perfect circles. In order to determine their form more accurately, their diameters were measured in three different directions parallel to the three directions of striæ, accordingly making angles approximately of 60° with one another. The measurements were made with a dividing instrument belonging to the Physical Institution of the University of Upsala; with that instrument lengths might be read off as near as $\frac{1}{1000}$ mm. It resulted from this examination that the melting-curve is a circle, if such casual irregularities are disregarded as are called forth by heterogeneity or unevenness of the wax layer. This result, as well as several of the physical properties set forth above, denotes the hexagonal system of crystallisation.

Summary.

We here put together the results obtained by the above examination of the physical and geometrical properties of graphite.

1. The striæ or ridges occurring in graphite crystals from different localities arise from twinning, which takes place in every ridge according to several different laws. If the mineral is supposed to crystallise hexagonally, two twinning laws suffice to explain the structure of the crystal-complex; whereas on the supposition of a less symmetrical system of crystallisation, this twinning becomes far more complicated.

2. The same sort of twin crystals as the natural ones may be artificially produced by bending crystal scales; thus it is evident that those surfaces which are twin-planes are also gliding-faces.

3. The percussion-figures of graphite may be referred to the gliding-faces, and are of another kind than the percussion-figures of micas and many other minerals.

4. The solid angles of graphite as well as the plane angles on the cleavage, show so little constancy that the geometrical structure of the mineral cannot be employed to determine the system of crystallisation.

5. The combustion- and etching-figures are regular hexagons.

6. The melting-curve of the cleavage is a circle, as far as can be ascertained by means of the methods that have been used.

7. *The nature of the twinning, together with the etching-figures and the melting-curve, make it probable that graphite crystallises in the hexagonal system. This is not contradicted by its geometrical properties, which are too inconstant to form the ground of any-decision on this point.*

Notes on a Recent Discovery of "Connellite."

By W. SEMMONS.

[Read March 10th, 1885.]

THE gradual decline in the production of copper from the mines of Cornwall and the consequent diminution of their number renders any discovery of a rare copper mineral an object of interest to all mineralogists.

Owing to the exhaustion of all the upper deposits, those products of decomposition—the beautiful arseniates and phosphates, &c. which adorn the cases of our national collection and those of private collections—are getting more and more scarce, and perhaps in the near future, so far as Cornwall is concerned, we shall have to rely for illustrations entirely on its past productions.

Probably one of the most beautiful of these minerals was the rare species "Connellite," a sulphato-chloride of copper found in small crystals of a deep blue colour, in copper veins traversing clay slate at Huel Providence and Huel Unity, also in a vein at Huel Damsel traversing granite. Huel Unity was a perfect storehouse of copper minerals, no less than fourteen combinations of that metal being found there, some of them being crystallised better than in any other mine; so that we might naturally look for good illustrations of Connellite here if any where.

Rashleigh in 1802 seems to have noticed the mineral from Wheal Providence, as a copper ore of an azure-blue colour composed of needle crystals.

Phillips in his 1828 edition does not, however, notice it.

Connel (Report British Association, 1847) gives an interesting account of its composition; while Dana, 1850, gives it a specific name.

Professor Maskelyne's paper (*Phil. Mag.* Jan. 1869) gives us by far the greatest information on the mineral, and one cannot help admiring the skill with which crystals of such minute size are there figured and described.

Bertrand has since (*Bull. Soc. Min.*, 1881, IV.) determined the mineral as optically uniaxial and positive.

Our knowledge of the mineral being therefore derived from very scanty material and from such old specimens, a detailed description of it from a new find in the Camborne district seems warranted. I have ventured too to give a detailed description of the associated minerals, and am able

to do this more fully than usual, as, owing to the miners not knowing Connellite, they have put aside specimens of other ores mistaking them for it. We owe our knowledge of this recent discovery largely to the energy of a local mineral dealer, Mr. Wm. Peters of Redruth.

The Camborne district is situated at the western end of the boss of granite in which most of the productive tin mines of the county are now worked. On the west and north flanks of this lies the killas (clay slate) for a distance of several miles, when we again meet with other outcrops of granite.

Like many other minerals which owe their existence to a peculiar combination of conditions, "Connellite does not seem to occur massive, and the little patches that appear compact resolve themselves into a mass of minute crystals. These are generally in radiating and divergent groups, but single crystals are occasionally found standing out distinct and alone."

Dr. Ch. O. Trechmann informed me he was not able to discern the di-hexagonal pyramid of Maskelyne under the microscope even with a power of 35. Dr. Trechmann has, however, since forwarded me a note giving a detailed description of the crystallographical characters of the mineral in two specimens I sent him. As mere extracts therefrom would in my opinion simply spoil the value of this note, I append it in full at the end of this paper.

In one specimen (received since Dr. Trechmann's examination) the crystals are so large that a hand lens of very low power enables one to determine their forms. I notice that we have here only the hexagonal pyramid and the di-hexagonal prism. The faces of the pyramid are unequally developed, some planes being developed at the expense of others as in some quartz crystals.

I am informed that a specimen in the collection of the Museum of Practical Geology also shows this almost complete obliteration of alternate planes.

The colour of the specimens I have seen is blue of various shades. In the well formed and larger crystals we have, when light passes through them, the most charming tints thrown up, and equalling the hues of the finest sapphire.

The other physical characters agree with those given in Dana, *System of Mineralogy*, page 627, as belonging to Connellite.

Associated with Connellite we have crystals of Brochantite of simple form, also very beautiful crystals of chalcophyllite; also cuprite, malachite, azurite, chalcocite and chalcopyrite.

The better way of describing their associations is perhaps to detail the way in which the minerals are found in the specimens produced.

No. 1.—The main mass of the stone consists of massive cuprite, which has been cut into patches by strings of malachite and Brochantite. On the upper surface are octahedral crystals of cuprite, and in sundry small cavities very well defined crystals of Brochantite. In some cases lying directly on the cuprite, and in other cases interlacing and covering the Brochantite, are transparent crystals of Connellite.

No. 2.—Crystals of cuprite (rhombic dodecahedra with slight development of octahedral faces) have a patch of Connellite crystals lying directly on them.

No. 3.—Compact mass of cuprite with traces of decomposition therein to only a small extent. The upper surface is covered with a layer from $\frac{1}{2}$ to $\frac{3}{4}$ inch thick composed of a mixture of compact and crystalline Brochantite with occasionally well defined crystals of the same mineral. Scattered over the surface and also in small cavities are well formed transparent crystals of Connellite.

No. 4.—A mass of compact cuprite, on which there is a small patch of malachite. This is covered in places with minute crystals of Connellite of a charming deep blue colour.

No. 5.—A most interesting stone; the main portion being cuprite, on and in which are malachite and Brochantite, some crystals of the latter being most distinct and perfect. On some undecomposed cuprite crystals are two radiating clusters of Connellite crystals having their terminal planes (hexagonal pyramid) beautifully developed. The crystals from centre of radiation to apex of pyramid are about $\frac{1}{4}$ inch in length, so that their form can be distinguished by the naked eye. The Connellite crystals too are found filling up the interstices between sheaves of radiating Brochantite crystals.

No. 6.—A stone almost entirely composed of azurite and malachite with cuprite. On the malachite is a layer of minute crystals of Brochantite, while a few very small crystals of Connellite are scattered over the stone.

No. 7.—Some minute radiated tufts of Connellite with malachite. Also some distinct crystals of chalcophyllite (copper mica) mixed with the malachite. In one small cavity there are pseudomorphs of malachite after chalcophyllite, the external cast only remaining as the interior is quite hollow. No cuprite found, but in its place copper pyrites.

No. 8.—Very beautiful and well defined hexagonal prisms of chalcophyllite on a base of chalcocite. The latter mineral is much decomposed. Again no trace of cuprite.

No. 9.—Decomposing chalcocite with radiated layers of small but brilliant crystals of chalcophyllite. Again no cuprite. We meet, too, here

with little tufts of minute bluish-green crystals which are probably Connellite.

The result of the above examinations tends to show that Connellite is most frequently associated with cuprite, Brochantite too being almost always present. The mineral, though, also occurs with chalcophyllite, but not so frequently.

We notice that chalcophyllite is found rather with the sulphides chalcocite and chalcopyrite, than with the oxide, cuprite.

Through the kindness of Mr. Thos. Davies, F.G.S., Mr. F. W. Rudler, F.G.S., and Mr. Pringle, I have, during the preparation of these notes, been able to examine the new and old specimens of Connellite in the National Collection at South Kensington, the Ludlam Collection and the Collection of the Museum of Practical Geology. I find the associated minerals with Connellite here also to be cuprite and Brochantite. Connellite in very minute crystals has recently been found in some stones from Marke Valley Mine, which is situate in the Eastern part of Cornwall, and therefore a long distance from any of the previously known localities. I have not been able to examine many of the Marke Valley specimens, but the general appearance of those I have seen is similar to those raised in the Camborne district.

The peculiar resemblance of the Brochantite to that from Peru, which I described to this Society (see *Mineralogical Magazine*, Vol. IV. p. 260), much interested me. There is also found frequently a peculiar amorphous-green copper mineral which gives reactions for both carbonate and sulphate, just as in the Peruvian specimens.

The Peruvian Brochantite was associated with decomposing Atacamite. Although I have not yet seen any trace of Atacamite in the Cornish specimens, it would not at all surprise me if we should find the Connellite has derived its chlorine from this mineral.

In conclusion, I trust that as probably sufficient materials are at hand, we may soon have presented to us a full and complete analysis of this rare and interesting combination.

On Monazite from Cornwall, and Connellite.

By H. A. MIERS, M.A.

Monazite from Cornwall.

[Read June 16th, 1885.]

A SPECIMEN of crystallised quartz and albite has recently been acquired for the British Museum which has a few isolated crystals of this rare mineral dispersed upon it. Conclusive evidence that the specimen comes from Cornwall is supplied both by the appearance of the quartz and albite and by the presence of the clay-slate with which they are associated.

The mineral monazite or Turnerite has hitherto been discovered in few localities and never in the British Isles. Anatase, however, is mentioned in Greg and Lettsom (*Manual of the Mineralogy of Great Britain and Ireland*, p. 863) as occurring at Tintagel and near Liskeard in Cornwall; and it is just possible that crystals of monazite may have been mistaken for anatase. Even if anatase has been found, it may be observed that the presence of one of these minerals is a ground for suspecting that the other may possibly occur in the same locality, as has been remarked by Hessenberg. Sphene, for which monazite might also have been mistaken, is not recorded from Cornwall; the specimen here described was detected by Mr. Davies as a new Cornish mineral, but was supposed to be sphene.

The crystals of monazite are approximately rectangular tables of the form shown in fig. 1, of a yellowish-brown colour. They are mostly from 1 to 2 mm. in length and breadth, and from $\frac{1}{2}$ to 1 mm. in thickness, and are thinly dispersed on one side of the specimen upon crystals of albite which overlie the quartz. In one instance, however, monazite is actually included in a crystal of quartz.

The following is a complete list of the forms which have been found upon Turnerite or monazite, including two new faces observed for the first time upon these Cornish crystals. A projection is given in fig. 1. (See p. 166.)

In addition to the well-determined faces given in this table, Phillips found two faces between *am* and *bm* respectively, and E. Dana, *American Journ. Scien.* xxiv. 1882, p. 247, found three between *sv*, *sv'* ($121 : 11\bar{1}$), and *re* respectively, to which definite indices cannot be assigned.

			I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	
a	100	$\infty P \infty$	p	P	P	M	a	c	p	a	c	Trechmann, Neues Jahrb. 1876, p. 598.
b	010	$\infty P \infty$	g ₁	K	K	P	b	b	g ₁	b	b	
c	001	0 P					c			c		
e	011	$P \infty$	m	M	M	e	e	m	e ₁	e	m	
u	021	$2 P \infty$	g ₃	l			u	l	g ₃	u	l	
g	012	$\frac{1}{2} P \infty$	h ₃	i				i	h ₃	g	i	
w	101	$-P \infty$	o ₁	a	a	e ^t	w	u	o ₁	w	u	
x	$\bar{1}01$	$P \infty$	a ₁	c	c		x	x	a ₁	x	x	
h	305	$-\frac{3}{8} P \infty$										
m	110	∞P	e ₁	e ₃	e	$\underline{e}$	m	e	m	M	e	of E. S. Dana.
l	210	$\infty P 2$	e ₂	e ₁		$\bar{a}$		v	e ₂	l	v	
y	310	$\infty P 3$								y	n	
n	120	$\infty P 2$		e ₆		$\underline{e}$	n			n	o	
r	111	$-P$		f		$\underline{a'}$	r		$d\frac{1}{2}$	r	z	
s	121	$-2P 2$				$\underline{o'}$	s			s		
v	$\bar{1}11$	P	b $\frac{1}{2}$	g ₁			v	r	b $\frac{1}{2}$	v	r	
i	$\bar{2}11$	$2 P 2$							b ₁	i	t	
z	$\bar{3}11$	$3 P 3$	b $\frac{3}{2}$					s	b $\frac{3}{2}$	z	s	
o	$\bar{1}21$	$2 P 2$	e ₃	e ₆				w	w	o	w	
d	$\bar{1}12$	$\frac{1}{2} P$								d		
t	$\bar{2}12$	$P 2$								t		
f	112	$-\frac{1}{2} P$										
q	701	$-7P \infty$										

- I. Lévy. *Annals of Philosophy*, xxi. 1823, p. 241.
II. Phillips. *Mineralogy*. 3rd Edition, 1823, p. 382.
III. Brooke. *Philosophical Magazine*, x. 1831, p. 189.
IV. J. D. Dana. *American Journal of Science*, xxxiii. 1838, p. 70.
V. Miller. *Phillips' Mineralogy*, 1852, p. 493. (Monazite.)
VI. Miller. *Phillips' Mineralogy*, 1852, p. 653. (Turnerite.)
VII. Descloizeaux. *Manuel de Minéralogie*, i. 1862, p. 533.
VIII. Kokscharow. *Materialien zur Mineralogie Russlands*, iv. 1862, p. 8.
XI. Vom Rath. *Poggendorff's Annalen*, cxix. 1863, p. 247.

FIG. 1

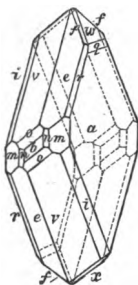
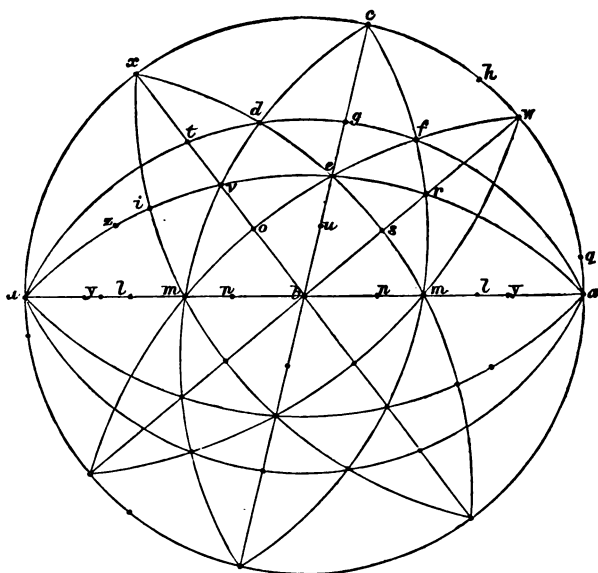


Fig. 2 shows a combination of all the forms found upon the Cornish crystals. The faces *f* and *q* are new. *f* is a small, well-defined face between *w* *e*; *q* a rounded face between *a* *w*.

	Calculated.		Observed.	
	°	'	°	'
<i>w f</i>	24	38½	24	36
<i>w q</i>	81	14½	81	48 approx.

With the exception of *b*, *o*, *m*, *w*, the faces are somewhat uneven, and do not give good reflections.

The measured angles agree closely with those of Kokscharow.

The following are some of the best:—

			Kokscharow.	
	°	'	°	'
<i>b m</i>	46	39	46	41½
<i>b o</i>	84	4	83	55
<i>o m</i>	85	58	85	58
<i>w m</i>	55	27	55	43
<i>w x</i>	93	0	93	1
<i>b v</i>	53	4	53	22

The measurements, however, though sufficient for the identification of the forms, are not good enough for the accurate determination of elements.

A crystal often has projecting from the faces, *v*, *e*, &c. corners of small crystals, which are united with itself by twinning upon the face *a*.

Connellite.

Several very fine specimens of this rare and beautiful Cornish mineral from Marke Valley and Camborne have lately been added to the British Museum Collection.

In comparison with what has formerly been found the crystals on the specimens from the latter locality are gigantic, some attaining a length of 2 to 4 mm., and having the terminal faces as much as 1 mm. in breadth.

The crystals are lustrous, and appear of a deeper blue than is common, owing to their greater thickness. They are closely united in radiating groups so as to form botryoidal and rounded masses. Isolated needles when they occur are small.

The matrix of the specimens is cuprite, with which are associated malachite and chrysocolla, the former occurring both massive and well crystallised. Chalcophyllite also appears on the Marke Valley, Brochantite and Chessylite on the Camborne specimens. Measurements made upon these crystals do not differ appreciably from those made upon minute needles by Prof. Maskelyne in 1863 (*Phil. Mag.* xxv. p. 89), and the habit of the crystals is that shown in Fig. 2, Plate II. of his description, but generally with the addition of the prism $b \{2\bar{1}1\} \propto P$ truncating the edges of $a \{10\bar{1}\} \propto P_2$.

The scalenohedral faces $ow \{94\bar{2}, 46\bar{7}\}$ are not to be found upon these crystals, although they seem to be so characteristic of the little needles previously described.

But one specimen is remarkable for a totally distinct habit of crystallisation. The Connellite here occurs in stout prisms *a b*, capped by the basal plane alone; the latter, however, is rounded and uneven, showing a tendency to form faces which are slightly inclined to the true basal plane. On this specimen, as in the case of the others, the crystals are mostly grouped so as to form rounded masses, but also occur isolated, and of the same habit.

One crystal has been found showing a combination of the prisms, hexagonal pyramid, and basal plane.

Notes on Northern Minerals.

By THOS. WALLACE, Esq., of Inverness.

(Communicated by the Local Secretary for Scotland.)

[Read June 16th, 1885.]

Barytes at Loch Bhruithaich (Bruiaich).

MY attention was first directed to this rock by Mr. Cruickshank, clerk of works at Beaufort Castle, in July of last year, when, from the description he gave of it, I ventured to pronounce it barytes. Specimens were soon after this put into my hands by Mr. Cruickshank, when I found that my conjecture was a correct one. There was another mineral associated with the barytes, of which we will speak afterwards. The specimens received were so very fine, that I resolved to visit the locality to be able to describe its surroundings and procure specimens for myself. This I did in May last in company with two of my colleagues and Mr. John Ross, one of Lord Lovat's gamekeepers, and who I believe was the first to call attention to this new locality.

General Description of Locality.

Loch Bruithaich, on the south shore of which this rock was found, is on Lord Lovat's property, and situated nine miles west of Beauly, with no regular road, however, within four miles of it. It lies encircled by hills in the very centre of one of the most interesting districts in the north, whether looked at geologically or archaeologically; but more especially the latter. The entire district is literally covered with tumuli, hut-circles, vitrified forts, and cup-marked stones. Every rising ground, in fact, seems to have been occupied as a place of defence by the primitive Celtic inhabitants. The loch is 942 feet above average sea-level, and contains an island with the remains of a crannoge, the position of which will be easily found with the aid of the accompanying map.

Geology.

By reference to the same map, the whole district from Beauly to the loch will be found covered with Old Red Sandstone. Around Beauly it furnishes capital building materials, the whole of Beaufort Castle, lately erected, being built of it.

As we proceed westwards, the lower Old Red Conglomerate begins to show itself at the surface at Kilmorack, and continues westward to Loch Bhruthaich, where it is bounded by the underlying metamorphic rocks. The old red surrounds the loch on the north, south, and east, while the west is bounded by the metamorphic rock. We might almost say that this loch occupies a basin in the Old Red Conglomerate measuring $1\frac{1}{4}$ miles long by half a mile broad.

The barytes is interbedded with the conglomerate at the south-east corner of the loch. It is exposed on the face of the cliff, and can be traced into the loch for a distance of twelve or fourteen yards.

Both conglomerate and barytes dip to the S.S.E. at an angle of 56° .

The thickness of the barytes bed varies from 12 to 14 or 15 inches.

It has an associated mineral of a semi-transparent nature, very friable, and one or two specimens showed a bluish tint resembling fluor spar.

I have sent specimens of both minerals to Mr. Iverson Macadam, who has kindly undertaken an analysis of them, which I hope will be in time to accompany these notes.

The only other locality known to me in the north where barytes is found is in Gollachy Burn, in the parish of Engie, Banffshire.*

This is one of three places north of the Grampians where we have contemporaneous volcanic rocks in the lower Old Red Sandstone. The other places are Rhynie, near Huntly, and the Shetland Islands.

At Gollachy, a thin vein of barytes runs through the broken rock that overlies the bed of diabase-porphyrityte.

NOTE.—Mr. Anderson, in his *Guide to the Highlands*, says:—"Near Little Struay, half a mile from the bridge, a lead mine situate in a thick vein of heavy spar, traversing gneiss, was some years ago (1847) opened by Lord Lovat, but for the present it has been abandoned."

Graphic Granite.

The gneiss of Kirkhill differs petrologically in different localities. At one place it is a hard compact contorted rock; at another it can be split into good roofing material; at another it assumes the form of a highly brecciated granitic rock, which in many places develops into graphic granite.

The arrangement of felspar in the latter is peculiar, being broken up

* *Geol. Trans.* Vol. iii. Part iii. p. 336.

into small pieces, which assume a laminar structure. This arrangement of the felspar with the quartz filling up the interstices produces the graphic form of granite. According to Lyell, "the crystals of felspar appear to have been formed first, leaving the space between them now occupied by the darker coloured quartz."

The other localities known to me in the north are Portsoy, Foyers, Lentrán, Rispond (Durnen), Lairg, and Ach-na-claich (Ardron).

Limestone of Kirkhill.

There is a considerable development of limestone interbedded with the metamorphic rocks of this district. Quarries have been wrought, but now entirely disused, at Kirkton, Blair-na-henachie, Wester Chines, and Rebeg.

At the latter place this industry was very successfully carried on for a good many years. The kilns were very skilfully constructed on an unusually large scale for this district. Great quantities were shipped, and for this purpose a canal was cut by the late proprietor.

The lime from this quarry was particularly adapted for building purposes.

The same limestone is found in Glenurquhart, Foyers, and Strathnairn.

It presents a variety of character, from soft argillaceous to highly crystalline forms. Different minerals are found associated with it in several places:—

At Wester Chines	...	Tourmaline.
„ Rebeg		Abriachanite* and reddle or raddle.
„ Foyers		Graphic Granite.
„ Glenurquhart		Allanite, pyrrhotite, sphene, zoisite, kyanite, Edenite, tremolite, actinolite, &c.

* For analysis see *Min. Mag.* Vol. III. pp. 65 and 66.

Connellite from Cornwall.

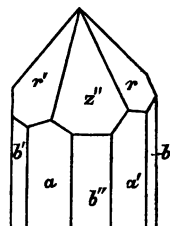
Note by Dr. C. O. TRECHMANN.

THE crystals are of a similar length, though often considerably thicker than those described by Prof. Maskelyne (*Phil. Mag.* Jan. 1863), and his general description applies to those under consideration.

They are, however, ill-adapted for measurement, as single perfect crystals are rare. As a rule several crystals are longitudinally attached to one another, with slight radial divergence, in such a manner that it becomes difficult or impossible to discriminate between the reflections of their minute faces.

The faces of the prismatic zone are rarely perfect, but more or less curved, and in some cases the pyramidal faces are quite rough.

The following is the result of the examination of two crystals, the first of which showed all the twelve faces of the forms *a* and *b*, while the second possessed two very brilliant pyramidal faces that gave distinct reflections:—



Forms—	Miller.	Naumann.
<i>r</i>	100	P
<i>z</i>	$\bar{1}22$	
<i>a</i>	10 $\bar{1}$	$\infty P2$
<i>b</i>	2 $\bar{1}1$	∞P
	C. O. T.	Maskelyne
	measured.	calculated.
<i>a b</i> =	80° approx.	30°0'
<i>r z''</i> =	47°31'	47°10'
<i>r b''</i> =	66°30'	66°25'

Combinations : *r, z, a; r, z, a, b.*

The bipyramidal form observed by Maskelyne was not developed on these crystals.

There is no doubt about the identity of this mineral with the Connellite described by Maskelyne, and it is interesting to note that its hexagonal symmetry has received a final confirmation by Bertrand (*Bull. de la Soc. Mineralog.*, 1881, IV. 88), who examined the cross section of a crystal and found it uniaxial.

*On the Chemical Composition of some Samples of Graphite from
Knock, Aberdeenshire.*

By W. IVISON MACADAM, F.C.S., F.I.C., &c. Lecturer on Chemistry,
School of Medicine; and Professor of Chemistry, New Veterinary
College, Edinburgh.

[Read June 16th, 1885.]

THE proportion of actual carbon varies much in different samples. Some portions are stated to have analysed as high as 75 per cent., but, as will be noticed from the figures given below, the carbon may be much lower.

			1	2	3
Carbon	...	...	17.61	22.85	82.76
Moisture and trace of	}	..	4.04	5.82	6.28
volatile matter					
Ash	...	...	78.85	71.83	60.96
			100.00	100.00	100.00

The material occurs in the railway cutting near Rothiemay station.

The carbon was estimated by fusion with an alkali, after extraction of the soluble portion with dilute acid and weighing the dried residue. This residue was afterwards ignited in a current of pure oxygen, and the carbonic anhydride weighed and calculated into carbon.

Analysis of a Sample of Strontianite from Strontian, Argyllshire.

By W. IVISON MACADAM, F.C.S., F.I.C., &c. Lecturer on Chemistry,
School of Medicine; and Professor of Chemistry, New Veterinary
College, Edinburgh.

[Read June 16th, 1885.]

THE samples to which this note refers were freshly cut from the quarries at Strontian. The mass differs much in quality, but is largely made up of the usual acicular groups. The colour of the mass as received varied, according to the composition, from a slight green shade where Strontianite predominated, to the more pure white of barium and calcium compounds.

The analyses were made from various portions, No. 1 being the selected Strontianite, No. 2 the more white portion of the mass. The results were as follows:—

		1	2
Strontium carbonate	...	94.502	56.601
Barium carbonate	...	0.214	0.051
Magnesium carbonate	...	—	0.416
Calcium carbonate	...	4.819	6.814
Plumbic sulphide	...	—	1.071
Strontium sulphate	...	—	21.248
Barium sulphate	...	—	10.014
Calcium sulphate	...	—	8.638
		99.535	99.858

The figures in analysis No. 1, when recalculated to the proportions of strontium oxide (Strontia), lime and carbonic anhydride, give the following results:—

Strontia	...	...	SrO	...	...	66.812
Lime	...	...	CaO	...	...	2.702
Baryta	...	...	BaO	...	...	0.166
Carbonic anhydride	...	...	CO ₂	...	...	80.855
						99.535

These results do not differ materially from those quoted by Dana, as analyses by Stromeyer, Thomson and Klaproth, of the mineral as found at Strontian.

Analysis No. 2 on recalculation yields :—

Strontia	...	...	...	SrO	...	51·660
Baryta	...	...	...	BaO	...	6·608
Lime	...	...	...	CaO	...	5·811
Magnesia	...	...	...	MgO	...	0·198
Lead	...	...	...	Pb	...	0·927
Sulphur	...	...	...	S	...	0·144
Sulphuric anhydride			..	SO ₃	...	14·853
Carbonic anhydride			...	CO ₂	...	20·152

99·853

I am not aware of any published results corresponding to this analysis of the crude mass. The proportions of the various minerals, as given above, have been calculated in the states of combination in which they evidently occur. In making the calculations I have been guided by the solubilities of the substances—weak acid dissolving out the carbonates, &c.

The carbonic anhydride found by actual analysis agreed with this assumption, whilst the insoluble sulphuric acid corresponded with the proportions of Strontia, &c. found after fusion, &c. of the portion insoluble in acids.

On the Chemical Composition of Butyrellite (Dana).

By W. IVISON MACADAM, F.C.S., F.I.C., &c. Lecturer on Chemistry,
School of Medicine; and Professor of Chemistry, New Veterinary
College, Edinburgh.

[Read June 16th, 1885.]

IN DANA'S *System of Mineralogy*, 5th Edition, 1883, page 747, the following description of this substance is given:—"Crystallisable in needles; butter-like in consistence; colour, white; melting point of impure native material, 47°, Brazier; but of material after solution in alcohol, 51°, Luck; 52°-52°·7, Brazier; easily soluble in alcohol or ether."

"Comp. $C_{32}H_{64}O_4$, Brazier = Carbon 75·0, hydrogen 12·5, oxygen 12·5 = 100, and like palmitic acid in ratio. The following are Williamson's analyses:—Nos. 1, 2, were the uncrystallised butyrite; 3, that obtained by combination with potash (with which it forms a kind of soap) and a separation afterwards with acid:—

			C.	H.	O.
1. Uncrystallised	...	...	73·78	12·50	18·72 = 100
2. " "	...	...	73·89	12·87	18·74 = 100
3. From Potash solution	...	...	75·05	12·56	12·89 = 100

Obs.—From the peat bogs of Ireland."

The only other notice of the substance with which I shall deal is one which occurs in Vol. XIX. of the *Proceedings of the Manchester Literary and Philosophical Society*, and is contained in a paper written by Mr. John Plant, F.G.S., &c. entitled *Bog Butter (Butyrellite) from Co. Galway, Ireland*. In this paper the author calls the substance a "mineral resin," and on page 70 says, "By the aid of scientific analysis, the substance called bog butter can be shown to be a perfectly natural production, arising from the decomposition of the vegetable matters growing the peat or bog," and "it is affirmed that the butter is sometimes found in small wooden kegs in bogs along the coast."

Following the advice of the last named author, I have submitted several samples of the bog butter to rigid chemical analysis, with the following results.

The samples collected for the investigation were ten in number, and were obtained as stated below.

- No. 1.—From Antiquarian Museum, Edinburgh; found in a *keg* in Glen Gell, Morvern, Argyllshire.
- No. 2.—From Co. Galway; collection of John Plant, Esq., F.G.S., and sample referred to in his paper.
- No. 3.—Locality unknown; from a “Mether” in the Museum of Science and Art, Edinburgh.
- No. 4.—Locality unknown; from the Museum of the Royal Irish Academy, Dublin.
- No. 5.—Broora Bog, County Derry, Ireland (1830); from the Belfast Academy Museum.
- No. 6.—County Down, Ireland; from the Belfast Academy Museum.
- No. 7.—Bog near Stranoant House, Co. Antrim, Ireland; from the Belfast Academy Museum.
- No. 8.—Kerry, Ireland; author's collection.
- No. 9.—Locality unknown; from Mayne collection, Museum of Science and Art, Edinburgh.
- No. 10.—Moss of Strathmore, Parish of Farr, Sutherlandshire, Scotland; Duke of Sutherland's collection, Golspie.

Sample 1 was a white solid, friable and greasy to the touch, with a cheese-like smell. Somewhat darkened on exposed surface. On the application of a heat of 100° C. (212° F.) the material melted readily to a clear yellow liquid, with floating solid particles very readily soluble in ether, and yielded, after evaporation at ordinary temperatures, a hard, slightly yellow mass, which on heating became a clear liquid with a yellow shade of colour. Fusing point $42^{\circ}\cdot 2$ C.; the ash of the original substance contained phosphoric acid.

Sample 2 was a white friable solid, somewhat greasy to the touch and with an odour resembling cheese. On heating, the material melted quickly to a clear yellow liquid with floating solid particles. Ether readily dissolved the sample, and on evaporation a hard yellow solid was obtained. Fusing point $47^{\circ}\cdot 2$ C.

Sample 3.—White, slightly friable, greasy, cheese-like smell. Heat readily melted the substance to clear yellow liquid with floating solid particles. Ether solution on evaporation gave a rich yellow solid. Fusing point $36^{\circ}\cdot 1$ C.

Sample 4.—White and very friable, greasy, cheese-like smell. Melted on application of heat to a clear slightly yellow liquid. Ether gave a hard white solid. Fusing point $47^{\circ}2$ C.

Sample 5.—Strong yellow colour, very slightly friable, cuts with knife, greasy, cheese-like smell. Heat readily melted the sample to a rich yellow oil with few floating particles. Ether gave a yellow hard mass. Fusing point $46^{\circ}1$ C.

Sample 6.—White and very greasy, could be moulded in fingers, butter-like smell. Melted to a clear slightly yellow liquid with floating solid particles. Ether gave a rich yellow and hard mass. Fusing point $37^{\circ}6$ C.

Sample 7.—Rich yellow colour, very slightly friable, greasy, butter-like smell. On heating, yielded a clear rich yellow oil with floating solid portions. Ether gave a hard solid with rich yellow colour. Fusing point $36^{\circ}1$ C.

Sample 8.—White, very friable, slightly yellow, greasy, butter-like smell. Melts very readily to a clear very slightly yellow liquid with floating solid particles. Ether gave a hard almost white substance. Fusing point $46^{\circ}6$ C.

Sample 9 was a white, slightly yellow, greasy solid, with an odour resembling butter. Very friable. Melted readily to a clear slightly yellow liquid with floating solid particles. Purification by means of ether gave a hard almost white solid, melting at $46^{\circ}6$ C.

Sample 10 was a white friable solid, with a cheese-like smell. Readily melted to a clear slightly yellow liquid. After solution in ether the resulting solid was white with a slight yellow tinge, and melted at 46° C.

The preliminary qualitative examination disclosed the presence of (1) fat, fatty acids, or material soluble in ether; (2) of a portion insoluble in ether but of an organic nature; (3) of a sugar, giving all the tests for the variety present in ordinary milk; and (4) of a residual ash, which in all cases contained a proportion of phosphoric acid.

The results of the quantitative analyses of the above constituents will be found on Table A., whilst the ultimate analyses of the samples will be found on Table B. and can readily be compared with the published analyses as given in Dana's *Mineralogy* and abstracted on Table C.

TABLE A.—ANALYSES OF SAMPLES OF BUTYRELLITE.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
Water	2·822	0·528	1·048	0·808	0·788	8·587	0·947	2·562	1·869	0·918
Portion soluble in Ether	97·252	98·948	96·808	98·818	95·468	91·517	97·194	98·955	97·260	98·452
Organic matter, insoluble in Ether	0·879	0·469	2·287	0·828	3·677	4·556	1·847	8·885	1·288	0·592
Ash or Mineral matter	0·047	0·058	0·861	0·055	0·065	0·384	0·011	0·096	0·187	0·084
	100·000	99·998	99·999	99·999	99·998	99·994	99·999	99·998	99·999	99·990

TABLE B.—ULTIMATE ANALYSES OF BUTYRELLITE.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.
Carbon	78·86	78·55	74·21	75·18	78·87	78·72	75·48	78·55	75·12	74·56
Hydrogen	12·48	12·88	12·52	12·56	12·14	12·86	12·25	12·74	12·81	12·68
Oxygen	18·66	14·12	18·27	12·81	14·49	18·40	12·27	18·71	12·57	12·76
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE C.—ULTIMATE ANALYSES OF BUTYRELLITE.

	Williamson.		Brazil.		Greg and Lettsom.	
	No. 1.	No. 2.	No. 1.	No. 2.	No. 1.	No. 2.
Carbon	78·78	78·89	75·0	78·98	78·98	75·65
Hydrogen	12·50	12·87	12·5	12·46	12·46	12·85
Oxygen	18·72	18·74	12·5	18·71	18·71	12·00
	100·00	100·00	100·0	99·50	99·50	100·00
Melting point	50°C.		47°C.	51°C.	51°C.	

TABLE A.—The following examination was made on the results of the purification by ether:—

1.—The ether solution was evaporated spontaneously, and afterwards heated on the water bath till a constant weight was established. The material was then treated with caustic soda and boiled. Salt was added to the mixture, and the separated curd removed and treated, after washing in small quantities of cold water, with sulphuric acid. The material so separated was allowed to stand until a firm cake was formed, which was then removed, and was found to consist of acids in all ways resembling those in ordinary butter. The liquid, after saponification with soda, was evaporated to almost dryness, and separated from the salt, which crystallised out. On exposure to heat the material evolved the odour of Acrolein, one of the products of the decomposition of glycerine by heat.

These experiments prove that the portion of the Butyrellite soluble in ether corresponded in all respects to the body obtained under like conditions from ordinary butter.

2.—The organic portion insoluble in ether was found to be to a slight extent soluble in water, and the solution on concentration gave faint but distinct evidence of the presence of *milk sugar* in very small proportions.

The portion left after treatment with water contained nitrogen, and gave when burned the peculiar "feathery" odour of burning cheese. *These tests are taken as indicating coesin similar to that found in milk.*

3.—The ash or mineral portion, as already stated, contained phosphoric acid in traces.

Taking all the above results into consideration, I am decidedly of opinion that Butyrellite has no claim to be called a "mineral," or to appear in textbooks of mineralogy. The fact that a large number of the samples of this substance were found, and still exist in barrels, and can be seen by any one who takes the trouble to visit the Museum of Antiquaries of Scotland, Edinburgh; or the Dublin Museum, or the Belfast Museum; that samples have been found wrapped in cloth or bearing the marks of woven cloth and covered with rushes or other plant fibre; that the substance is only found in peat bogs (noted for their powers of arresting decomposition); and lastly, that tradition speaks of the butter-dyke or butter-safe being dug in bogs, all point to the material being of veritable animal origin, and having nothing in common with the mineral kingdom.

But outside of all this mass of evidence, chemical, circumstantial, and traditional, the butter—for butter it is—has its own story to tell. One and all of the samples on being broken across, or still better when treated with ether, yield to the observer a number of *hairs*, which on being examined

under the microscope can be readily identified as resembling in all respects *cow's hair*, and in one case at least the very same bog has furnished not only *bog butter* but *heads of oxen*—these heads having still attached to them hairs exactly corresponding to those imbedded in the butter.

As to how these kegs and masses of butter found their way into the positions from which they are now obtained we cannot here discuss ; it is sufficient for our purpose to show that the material is not of mineral or even of resin origin, but of undoubted animal derivation. The material should therefore be erased from mineral lists.

On an Occurrence of Rare Copper Minerals from Utah.

By G. S. MACKENZIE, Ph.D., F.I.C,

[Read 16th June, 1885.]

IN the American Eagle Mine, Utah Territory, occur in intimate association with olivenite and other copper compounds, two copper minerals of an interesting and rare composition.

Conichalcite.—Covering the surface of often large pieces of more or less friable mixed arseniates, sometimes forming a complete green coating, are numbers of beautiful emerald-green globules. In consequence of the firm adherence of the base of the globules to the underlying gangue matter, it was difficult to obtain material pure enough for analysis, and therefore the results given below lay no claim to great accuracy.

Conichalcite from Spain.

CuO	...	...	28.59	81.76
CaO	...	...	19.67	21.36
MgO	...	...	0.61	—
ZnO	...	...	2.75	—
Ag	...	...	.29	—
As ₂ O ₅	...	...	39.80	30.68
P ₂ O ₅	...	...	0.20	8.81
V ₂ O ₅	...	...	—	1.78
H ₂ O	...	...	5.55	5.61
Fe ₂ O ₃	...	...	0.45	—
CO ₂	...	...	0.98*	—
Quartz	..	...	1.11	—
			100.00	100.00

* By difference.

The ferric oxide was derived from adhering gangue matter. The carbon dioxide was most likely combined with lime, as the temperature required for its expulsion was very much higher than that at which all the water was driven off.

The silver seems to be present in an oxidised state as silver arseniate, since nitric acid takes it all into solution, and no sulphide or native silver could be detected.

This mineral resembles very much conichalcite, found hitherto only in Andalusia in Spain. The analysis, as represented in Dana's system of mineralogy, is given above for comparison. The Utah mineral differs from the Spanish one in containing no vanadium, and having seemingly part of the copper replaced by zinc. Phosphorus is also almost wanting.

Chenevixite.—Scattered in patches throughout such parts of the ore as occur in hard lumps is a greenish opaque body, with little or no lustre, corresponding very well in composition with analysis of chenevixite from Cornwall, as given in Dana's *Mineralogy*.

				<i>Chenevixite from Cornwall.</i>
CuO	...	...	26.88	31.70
CaO	...	...	0.55	0.84
MgO	...	...	0.23	—
Fe ₂ O ₃	...	...	26.94	25.10
Al ₂ O ₃	...	...	1.17	—
As ₂ O ₃	...	...	84.62	92.20
P ₂ O ₅	...	...	—	2.80
H ₂ O	...	...	9.25	8.66
Quartz	...	...	.71	—
100.85				100.80

Before the blowpipe the two minerals react the same, giving off arsenical fumes and leaving a black magnetic residue.

INDEX TO MINERALOGICAL PAPERS, &c. 1883.

By H. A. MIERS, M.A.,

(SECOND PART.)

[Continued from page 144.]

- ADULARIA. T. Münster. *Nyt. Mag.* xxvii. p. 309. *Kongsberg*.
V. Zepharovich. *Lotos.* xxxi. p. 1. *Zillergrund*.
- ALBITE. T. Münster. *Nyt. Mag.* xxvii. p. 309. *Kongsberg*.
C. Friedel and E. Sarasin. *C. R.* xcvi. p. 290. *Art*.
- ALUNITE. P. Jeremejew. *Verh. Min. Ges. St. Pet.* xviii. p. 221. *Buchara*.
- AMPHIBOLE. A. Kalcinszky. *Chem. Cent. Bl.* p. 217.
- ANALCIME. A. Ben Saude. *J. Ac. Sc. Lisb.* p. 172. *Cryst. opt.*
v. Copper.
- ANGLESITE. P. Jeremejew. *Verh. Min. Ges. St. Pet.* xviii. p. 108. *Cerusite after*.
- ANHYDRITE. A. Gorgeu. *C. R.* xcvi. p. 1734. *Art*.
- ANTHRACITE. G. Laube. *Verh. Geol. Reichs.* p. 249. *Niklasberg*.
T. Münster. *Nyt. Mag.* xxvii. p. 309. *Kongsberg*.
V. Zepharovich. *Lotos.* xxxi. p. 6. *Stillupthal*.
- APATITE. A. Ditte. *C. R.* xcvi. p. 575. *Art*.
J. Vogt. *Geol. För. Stock.* vi. p. 788. *Loc*.
- ARGENTITE. T. Münster. *Nyt. Mag.* xxvii. p. 309. *Kongsberg*.
- ARSENITE. J. Krenner. *Ber. Ung.* i. p. 170. *Cryst*.
- AUGITE. v. Amphibole.
- AXINITE. T. Münster. *Nyt. Mag.* xxvii. p. 309. *Kongsberg*.
- BARYTES. W. Downes. *Trans. Devon. Ass.* xv. p. 453. *Chudleigh*.
A. Gorgeu. *C. R.* xcvi. p. 1734. *Art*.
- BAUXITE. L. Mayer and O. Wagner. *Dingl. J.* cxlviii. p. 213. *Chem.*
and *Chem. Cent. Bl.* p. 558.
- BLÉNDE. E. Doll. *Verh. Geol. Reichs.* p. 143. *Pseud. after Galena*
and *Barytes*.
T. Münster. *Nyt. Mag.* xxvii. p. 309. *Kongsberg*.
J. Loczka. *Ber. Ung.* i. p. 10. *Chem*.
- BRUCITE. C. Friedel. *Att. Ac. Tor.* xviii. p. 75. *Chem*.
A. Weisbach. *N. J.* (2), p. 119. *Chem*.
- CALCITE. T. Münster. *Nyt. Mag.* xxvii. p. 309. *Kongsberg*.
V. Zepharovich. *Lotos.* xxxi. p. 1. *Zillergrund*.

- CALEDONITE.** P. Jeremejew. Mém. Ac. St. Pet. xxxi. No. 16. *Cryst.*
CANCANINITE. G. Lindström. Geol. För. Stock. vi. p. 549. *Chem.*
CASSITERITE. v. Eibenstock.
CELESTINE. A. Gorgeu. C. R. xvi. p. 1734. *Art.*
CERUSSITE. P. Jeremejew. Verh. Min. Ges. St. Pet. xviii. p. 108. *After Anglesite.*
CHLORITE. T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
CINNABAR. E. Doll. Verh. Geol. Reichs. p. 141. *Pseud. after Fahlerz.*
COALS. C. John. Verh. Geol. Reichs. p. 99. *Chem.*
COPPER AND ANALCIME. F. Zschau. Isis. Ber. pp. 26, 75. *Plauen.*
COPPER PYRITES. T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
CORDIERITE. E. Hussak. Ber. Ak. Wien. lxxvii. (1) p. 332.
CRYOLITE. J. Krenner. Ber. Ung. i. p. 15. *Cryst.*
CRYSTALLISATION. G. Brügelmann. Chem. Cent. Bl. p. 471.
CRYSTALLOGRAPHY. L. Sohncke. Verh. Nat. Ver. Karls. ix. Abh. p. 1.
CRYSTALS. A. Ben Sande. J. Ac. Sc. Lisb. p. 172. *Cubic. opt.*
G. Basso. Mem. Ac. Tor. xxxiv. p. 3. *Opt.*

DESMINE. V. Zepharovich. Lotos. xxxi. p. 1. *Zillergrund.*
DIAMOND. T. Schrader. Isis. Abh. p. 65. *C. Good Hope.*
DOPPLERITE. A. Mayer. Chem. Cent. Bl. p. 699. *Chem.*

EIBENSTOCK. Schröder. Ber. Nat. Ges. Leipz. p. 70. *Cassiterite of.*
ELATERITE. v. Helenite.
EMPLECTITE. J. Krenner. Földt. Köz. xiii. p. 269. *Rezbanya.*
ENCLOSURES. G. Merrill. Science, i. p. 221. *Sandstone.*
EVIGTOKITE. W. Flight. J. Chem. Soc. xliii. p. 141. *Chem.*

FLUOR. T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
FRANKLINITE. P. Ricketts. Eng. Min. J. xxxv. p. 235. *Chem.*

GADOLINITE. C. Welsbach. Chem. Cent. Bl. p. 586 : and Zts. Physiolog. Chem. vii. p. 630.
GALENA. T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
GARNET. M. Weibull. Geol. För. Stock. vi. p. 503. *Chem.*
V. Zepharovich. Lotos. xxxi. p. 6. *Stillupthal.*

HEMATITE. E. Doll. Verh. Geol. Reichs. p. 143. *Pseud. after Garnet.*
E. Wethered. Rep. Brit. Ass. 1882, p. 533. *Min.*
V. Zepharovich. Lotos. xxxi. p. 1. *Zillergrund.*
HARMOTOME. A. Gorgeu. C. R. xvii. p. 1144. *Art.*
HAUSMANNITE. A. Nawratil. Chem. Cent. Bl. p. 568. *Var. Elaterite ; and*
HELENITE. Dingl. J. cxxlviii. p. 513.

IDOCRASE. E. Ludwig and A. Benard. Chem. Cent. Bl. p. 193.
IGELSTRÖMITE. M. Weibull. Geol. För. Stock. vi. p. 500. *Chem.*
IRON. E. Steenstrup and J. Lorenzen. Zts. Geol. Ges. Berl. xxxv. p. 695. *Greenland.*

- JADEITE.** A. Arzruni. Zts. Ethn. xv. p. 163. *Min.*
- KAOLINITE.** A. Lindström. Geol. För. Stock. vi. p. 416. *Min.*
- KONGSBERG.** T. Münster. Nyt. Mag. xxvii. p. 309. *Minerals of.*
- LAUMONTITE.** T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
V. Zepharovich. Lotos. xxxi. p. 6. *Stillupthal.*
- LAXMANNITE.** N. Kokscharow. Verh. Min. Ges. St. Pet. xviii. p. 131. *Cryst.*
- LINARITE.** P. Jeremejew. Mém. Ac. St. Pet. xxxi. No. 16. *Cryst.*
- LISKEARDITE.** W. Flight. J. Chem. Soc. xliii. p. 141. *New Min.*
- MAGNETITE.** H. Vater. Isis. Ber. p. 27. *Berggiesshübel.*
- MANGANESE-MINERALS.** M. Weibull. Geol. För. Stock. vi. p. 499. *Dalarne, Chem.*
- MANGAN-HEDENBERGITE.** M. Weibull. Geol. För. Stock. vi. p. 505. *Chem.*
- MANGANOCALCITE.** J. Krenner. Ber. Ung. i. p. 201. *Min.*
- MARCASITE.** E. Doll. Verh. Geol. Reichs. p. 141. *Pseud. after Blende.*
- MENEHINITE.** J. Krenner. Földt. Köz. xiii. p. 345. *Cryst.*
- MINERALS.** F. Sandberger. Verh. Phys. Ges. Würz. xviii. (2). *Genesis of.*
- NEPHRITE.** W. Beck and J. Muschketow. Verh. Min. Ges. St. Pet. xviii. p. 1. *Min.*
J. Krenner. Ber. Ung. i. p. 203. *Min.*
A. Meyer. Isis. Abh. pp. 75, 77.
A. Arzruni. Zts. Ethn. xv. p. 163. *Min.*
- NEWBERYTE.** A. Schmidt. Termes. Füzet. vi. p. 164. *Cryst.*
- NEW MINERALS.** v. Helenite, Liskeardite.
- ORPIMENT.** J. Krenner. Földt. Köz. xiii. p. 269. *Bosnia.*
- PACHNOLITE.** N. Kokscharow. Verh. Min. Ges. St. Pet. xviii. pp. 139, 230. *Cryst.*
J. Krenner. Ber. Ung. i. p. 166. *Cryst.*
- PERICLINE.** V. Zepharovich. Lotos. xxxi. p. 6. *Stillupthal.*
- PHENAKITE.** G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 100.
- PITCHBLEND.** H. Foullon. Verh. Geol. Reichs. p. 95. *Decomposition Products.*
W. Brögger. Geol. För. Stock. vi. p. 744. *Norway.*
- PSEUDOMORPHS.** E. Doll. Verh. Geol. Reichs. p. 141.
- PYRITES.** J. Garland. Trans. Geol. Soc. Corn. x. p. 161. *Senjen.*
T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
- PYRRHOTINE.** T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
- QUARTZ.** E. Doll. Verh. Geol. Reichs. p. 143. *Pseud. after Garnet.*
T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
V. Zepharovich. Lotos. xxxi. p. 6. *Stillupthal.*

- RALSTONITE.** J. Krenner. Ber. Ung. i. p. 172. *Cryst.*
REALGAR. J. Krenner. Földt. Köz. xiii. p. 269. *Bosnia.*
RHODOCHROSITE. M. Weibull. Geol. För. Stock. vi. p. 507. *Chem.*
RHODONITE. A. Gorgeu. C. R. xvii. p. 320. *Art.*
V. Fino. Att. Ac. Tor. xviii. p. 39. *Viù.*
RUTILE. V. Zepharovich. Lotos. xxxi. p. 6. *Stillupthal.*
- SALT.** V. Ball. Rep. Brit. Ass. 1882, p. 530. *India.*
SCHWEITZERITE. J. Krenner. Földt. Köz. xiii. p. 269. *Min.*
SOOLECITE. V. Zepharovich. Lotos. xxxi. p. 1. *Zillergrund.*
SILFBERGITE. M. Weibull. Geol. För. Stock. vi. p. 504. *Chem.*
SILVER. T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
SPHENE. V. Zepharovich. Lotos. xxxi. p. 6. *Stillupthal.*
STEAHITE. E. Doll. Verh. Geol. Reichs. p. 144. *Pseud. after Dolomite and Quartz.*
STEPHANITE. T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
STIBNITE. J. Krenner. Földt. Köz. xiii. p. 350. *Japan.*
STILLUPTHAL. V. Zepharovich. Lotos. xxxi. p. 6. *Minerals of.*
STROMTIANITE. F. Schalch. Ber. Nat. Ges. Leipz. p. 76. *Wildenau.*
SULPHUR. E. Divers and M. Shimosé. Rep. Brit. Ass. 1882, p. 487. *Japan.*
Gellhorn. Mitth. Nat. Ver. Frankf. i. p. 1. *Min.*
- TEPHROITE.** A. Gorgeu. C. R. xvii. p. 320. *Art.*
TROMSENLITE. J. Krenner. Ber. Ung. i. p. 162. *Cryst.*
- URANOTHALLITE.** A. Brezina. Verh. Geol. Reichs. p. 269. *Cryst. and Chem.*
- VAUQUELINITE.** N. Kokscharow. Verh. Min. Ges. St. Pet. xviii. p. 131. *Cryst.*
- WAD.** M. Weibull. Geol. För. Stock. vi. p. 508. *Chem.*
WAGNERITE. A. Ditte. C. R. xvii. p. 846. *Art.*
WALUEWITE. P. Nicolajew. Verh. Min. Ges. St. Pet. xviii. p. 226. *Chem.*
WILLEMITE. P. Ricketts. Eng. Min. J. xxv. p. 235. *Chem.*
WITHERITE. W. Hankel. Pogg. xviii. p. 425. *Thermoeol.*
WOLFRAM. T. Münster. Nyt. Mag. xxvii. p. 309. *Kongsberg.*
WULFENITE. N. Kokscharow. Verh. Min. Ges. St. Pet. xviii. p. 139. *Cryst.*
- XENOTIME.** W. Brögger. Geol. För. Stock. vi. p. 744. *Norway.*
- ZILLERGRUND.** V. Zepharovich. Lotos. xxxi. p. 1. *Minerals of.*
ZINCITE. P. Ricketts. Eng. Min. J. xxv. p. 235. *Chem.*

LIST OF ABBREVIATIONS USED IN INDEX.

ABH. GES. GÖTT.	Abhandlungen d. kön. Ges. d. Wissenschaften zu Göttingen.
ABH. NAT. GES. GÖRL.	Abhandlungen d. naturforschenden Gesellschaft zu Görlitz.
ABH. NAT. VER. BREM.	Abhandlungen heraus. naturwissens. Vereine zu Bremen.
ABH. SENCK. GES.	Abhandlungen der Senckenbergischen naturforschenden Gesellschaft. Frankfurt-a-M.
ACT. AC. BORD.	Actes de l'Académie nationale des sciences, belles lettres et arts de Bordeaux. Bordeaux.
ACT. UN. LUND.	Acta Universitatis Lundensis. Lund.
ANN. MUS. GEN.	Annali del Museo Civico di Storia Naturali di Genova. Genova.
ANN. NAT. HIST.	The Annals and Magazine of Natural History. London.
AN. SOC. ESP. HIST. NAT.	Anales de la Sociedad Española de Historia Natural. Madrid.
ANZ. AK. WIEN.	Anzeiger der k. Akademie der Wissenschaften. Wien.
ARCH. NÉERL.	Archives néerlandaises des sciences exactes et naturelles. Haarlem.
ARCH. SC. PHYS. NAT.	Bibliothèque Universelle. Archives des Sciences Physiques et Naturelles. Genève.
ARCH. VER. FR. MECK.	Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg. Güstrow.
ART.	Artificial.
ASS. FR.	Association française pour l'avancement des sciences. Paris.
ATT. AC. GIOEN.	Atti dell' Accademia Gioenia di Scienze Naturali in Catania. Catania.
ATT. AC. LINC.	Atti della R. Accademia dei Lincei (memorie della classe di scienze fisiche, matematiche e naturali). Roma.
ATT. AC. PONT.	Atti dell' Accademia Pontificia di Nuovo Lincei. Roma.
ATT. AC. TOR.	Atti della Reale Accademia della Scienze di Torino.
ATT. IST. VEN.	Atti del reale Istituto Veneto di Scienze, Lettere ed Arto. Venezia.
ATT. SOC. IT. MIL.	Atti della Società Italiana di Scienze Naturali. Milano.
ATT. SOC. NAT. MOD.	Atti della Società dei Naturalisti di Modena. Modena.
ATT. SOC. TOSC.	Atti della Società Toscana di Scienze Naturali. Pisa.
BER. BÖHM. GES.	Sitzungsberichte d. k. böhm. Gesellschaft der Wissenschaften. Prag.
BER. CHEM. GES. BERL.	Berichte der deutschen chemischen Gesellschaft zu Berlin.
BER. NAT. GES. DORP.	Sitzungsberichte der naturforschenden Gesellschaft. Dorpat.
BER. NAT. GES. HALLE.	Bericht über die Sitzungen der Naturforschenden Gesellschaft zu Halle.
BER. NAT. GES. LEIPZ.	Sitzungsberichte der naturforschenden Gesellschaft zu Leipzig.

- BER. PHYS. GES. WURZ.** Sitzungsberichte der physikalisch medicinischen Gesellschaft zu Würzburg.
- BER. UNG.** Mathematische und naturwissenschaftliche Berichte aus Ungarn. Berlin.
- BULL. AC. BELG.** Bulletin de l'Académie Royale des Sciences Belgique. Bruxelles.
- COMM. AT. BRESC.** Commentari dell' Ateneo di Brescia. Brescia.
- DANSK. VID. SELSK. SKR.** Kongelige danske videnskabers Selskab (Skrifter). Copenhagen.
- DENKS. AK. WIS. WIEN.** Denkschriften der kaiserlichen Akad. der Wissenschaften. Wien.
- DENKS. SCHW. GES.** Neue Denkschriften d. allgemeinen schweizischen Gesellschaft f. die gesammten Naturwissenschaften. Zürich.
- DINGL. J.** Dingler's Polytechnisches Journal. Stuttgart.
- ENG. MIN. J.** The Engineering and Mining Journal. New York.
- FÜLDT. KÖZ.** Földtani Közlöny. Budapest.
- GEOL. FÖR.** Geologiska Föreningens i Stockholm. Förhandlingar. Stockholm.
- GEOL. MAG.** Geological Magazine. London.
- ISIS (BER. AND ABH.).** Sitzungsberichte und Abhandlungen der naturwissenschaftlichen Gesellschaft Isis. Dresden.
- JAHRB. HAMB. ANST.** Jahrbuch der Hamburgischen wissenschaftlichen Anstalten. Hamburg.
- JAHRB. NASS. VER.** Jahrbuch des Nassauischen Vereins für Naturkunde. Wiesbaden.
- JAHRB. ANN. BUCH. VER.** Jahresbericht des Annaberg-Buchholzer Vereins für Naturkunde. Annaberg-in-S.
- JAHRB. BÖHM. GES.** Jahresbericht d. k. Böhm. Gesellschaft der Wissenschaften Prag.
- JAHRB. NAT. VER. RHEIN.** } Jahresbericht der Pollichia eines naturwissenschaftlichen Vereins der Rheinpfalz. Dürkheim a-d-Hart.
- JAHRB. VER. WÜRTT.** Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg. Stuttgart.
- J. AC. SC. LISB.** Jornal de Sciencias Mathematicas Physicas e Naturaes publicado sob os auspicios da Academia Real das Sciencias de Lisboa.
- J. CHEM. SOC.** Journal of the Chemical Society. London.
- J. MIC. SOC.** Journal of the Royal Microscopical Society. London and Edinburgh.
- J. NAT. GES. ZÜR.** Vierteljahrschrift der schweizerischen naturforschenden Gesellschaft in Zürich. Zürich.
- J. QUECK.** Journal of the Queckett Microscopical Club. London.

LOTOS.	Lotos Jahrbuch für Naturwissenschaft. Prag.
MAANDBL.	Maandblad voor Naturwetenschappen. Amsterdam.
MEDD. NAT. FOR. COP.	Videnskabelige Meddelelser fra den naturhistoriske Forening i Kjøbenhavn. Copenhagen.
MÉM. AC. AM.	Mémoires de l'Académie des Sciences, des Lettres, et des Arts d'Amiens.
MÉM. AC. BELG.	Mémoires de l'Académie Royale des Sciences, des Lettres, et des Beaux-arts de Belgique. Bruxelles.
MEM. AC. BOL.	Memorie della Accademia delle Scienze dell' Istituto di Bologna.
MÉM. AC. SAV.	Mémoires de l'Académie des Sciences, Belles Lettres, et Arts de Savoie. Chambéry.
MÉM. AC. ST. PET.	Mémoires de l'Académie Impériale des Sciences de St. Petersburg.
MEM. AC. TOR.	Memorie della Reale Accademia della Scienze di Torino.
MEM. SOC. NAT. MOD.	Memorie della Società dei Naturalisti di Modena. Modena.
MIN. MAG.	Mineralogical Magazine and Journal of the Mineralogical Society. London.
MITTH. NAT. VER. FRANK.	Monatliche Mittheilungen des naturwissenschaftlichen Vereins. Frankfurt-a-Oder.
MITTH. NAT. VER. STEIER.	Mittheilungen des naturwissenschaftlichen Vereines für Steiermark. Graz.
MITTH. UNG. GEOL. ANST.	Mittheilungen aus dem Jahrbuche der kön. Ungarischen geologischen Anstalt. Budapest.
NAT. TIDDS.	Naturhistorisk Tiddsskrift. Copenhagen.
NATURE.	Nature. London and New York.
NEPS. TERM. EL.	Nepszerü Termeszettudományi Előadások Gyűjteményi. Budapest.
NORSK. VID. SELS. SKR.	Det kongelige Norske Videnskabers Selskabs (Skrifter). Thordhjem.
NOV. ACT. AC. CAES.	Nova Acta Academiae Caesareae Leopoldino-Carolinae Germanicae Naturae curiosorum. Halle.
NOV. ACT. SOC. UPS.	Nova Acta Regiae Societatis Scientiarum Upsaliensis. Upsala.
NYT. MAG.	Nyt Magazin for Naturvidenskaberne. Christiania.
PHIL. TRANS.	Philosophical Transactions of the Royal Society of London.
PREIS. JAB. GES.	Preisschriften von der Jablonowski'schen Gesellschaft zu Leipzig. Leipzig.
PROC. AM. PHIL. SOC.	Proceedings of the American Philosophical Society. Philadelphia.
PROC. COTTES. NAT.	Proceedings of the Cotteswold Naturalists' Field Club. Gloucester.
PROC. IRISH AC.	Proceedings of the Royal Irish Academy. Science. Dublin.
PROC. PHIL. SOC. GLASG.	Proceedings of the Philosophical Society of Glasgow. Glasgow.

PROC. PHIL. SOC. MAN.	Proceedings of the Manchester Literary and Philosophical Society. Manchester.
PROC. ROY. SOC.	Proceedings of the Royal Society of London.
PROC. ROY. SOC. ED.	Proceedings of the Royal Society of Edinburgh.
PSEUD.	Pseudomorph.
Q. J. MIC. SC.	Quarterly Journal of Microscopical Science. London.
RAD. JUGO. AK.	Rad Jugoslavenske Akademije Znanosti i Umjetnosti. Zagrebu.
RENDIC. AC. BOL.	Rendiconto delle sessioni dell'Accademia Reale delle Scienze dell'Istituto di Bologna. Bologna.
RENDIC. IST. LOMB.	Reale Istituto Lombardo di scienze e lettere. Rendiconti. Milano.
REP. BRIT. ASS.	Report of the British Association for the Advancement of Science. London.
REP. DEV. ASS.	Report and Transactions of the Devonshire Association. Plymouth.
REV. Q. SC. BR.	Revue des Questions scientifiques. Bruxelles.
SCHR. GES. DANZ.	Schriften der naturforschenden Gesellschaft zu Danzig. Danzig.
SCHR. PHYS. GES. KÖNIGS.	} Schriften der Physikalisch-ökonomischen Gesellschaft. Königsberg.
TERMES. FÜZET.	Termeszettajzi Füzetek kiadja a magyar nemzeti muzeum. Budapest.
TERMES KÖZ.	Termeszettudományi Közlöny. Budapest.
TRANS. DEVON. ASS.	Devonshire Association for the Advancement of Science, &c London and Plymouth
TRANS. GEOL. SOC. CORN.	Transactions of the Royal Geological Society of Cornwall, Penzance.
TRANS. ROY. SOC. ED.	Transactions of the Royal Society of Edinburgh. Edinburgh.
VERH. AK. VET. AMST.	Verhandelingen der koninklijke Akademie van Wetenschappen. Amsterdam.
VERH. GEOL. REICHS.	Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt. Wien.
VERH. GES. ERDK.	Verhandlungen der Gesellschaft für Erdkunde zu Berlin.
VERS. MED. AK. AMST.	Verslagen en Mededeelingen der koninklijke Akademie van Wetenschappen. Amsterdam.
VERH. NAT. VER. BRÜNN.	Verhandlungen des naturforschenden Vereines in Brünn.
VERH. PHYS. GES. WURZ.	Verhandlungen der physikalisch medicinischen Gesellschaft zu Würzburg.
VERH. RUSS. MIN. GES.	Verhandlungen der russisch kaiserlichen mineralogischen Gesellschaft zu St. Petersburg.
VERH. SCH. GES. ZÜR.	Verhandlungen der schweizerischen naturforschenden Gesellschaft in Zürich. Zürich.

VERH. NAT. VER. KARLS. Verhandlungen des naturwissenschaftlichen Vereins in
Karlsruhe.

ZTS. ANAL. CHEM. Zeitschrift für analytischen Chemie. Wiesbaden.

ZTS. ETHN. Zeitschrift für Ethnologie. Berlin.

ZTS. GEOL. GES. BERL. Zeitschrift der deutschen geologischen Gesellschaft. Berlin.

ZTS. NATURWISS. JENA. Jenaische Zeitschrift für Naturwissenschaft. Jena.

Abstracts.

H. FOERSTNER.—*Ueber künstliche physikalische Veränderungen der Feldspäthe von Pantelleria.* (*Zeits. f. Krystallographie u. Mineralogie* IX. p. 333.)

The felspars of Pantelleria are (1) potash-plagioclase, and (2) soda-orthoclase.

(1). The Anorthic felspars form a chemical and crystallographical series from that of Mt. Gibele, for which $K_2O : Na_2O = 1 : 4 \cdot 29$, to that of Cuddia Mida, for which $K_2O : Na_2O = 1 : 2 \cdot 29$. With the exception of the first they all become optically oblique during or after heating to various temperatures, and the temperature required to produce the change decreases through the series from 300° to 86° in the case of the Cuddia Mida felspar.

The felspar of Mt. Gibele remains unchanged at 500° , as do the potash-plagioclases of other localities.

The plagioclase of Cuddia Mida, which is most easily transformed, is isodimorphous with, and stands very near to the soda-orthoclase in both form and composition, and simulates an oblique form by twinning; so that, as is also the case with boracite, leadhillite, leucite, and tridymite, these pseudosymmetrical twins assume optical properties corresponding to their form when they are heated.

On cooling, the extinction angle returns to its original value of about 2° , but the lamellations are permanently changed; the felspar of Cuddia Mida alone retains occasional oblique patches, and optical anomalies.

(2). The soda-orthoclase is unaltered while being heated, but during cooling becomes in parts optically anorthic, finally returning in part or entirely to its original character. During the cooling numerous varieties of lamellation and changes of extinction angle are produced.

The author regards potash and soda-felspar as isodimorphous, each having a stable and an unstable form; in the potash-plagioclase, therefore, the former is in its unstable modification, and only adopts the other when heated; the same is true of soda-felspar in the soda-orthoclase. The potash-plagioclase, therefore, originally crystallised in the oblique form (as boracite in the cubic), and was changed in cooling, with the exception of the variety mentioned above as unaltered by heating, which is also the farthest in the series from orthoclase. Of the two nearly identical

felspars, plagioclase from Cuddia Mida, and the soda-orthoclase (2), the latter probably crystallised more slowly and under less pressure than the former. The author found that by means of pressure he could induce in the soda-orthoclase the twin striations of a plagioclase, and lamellæ with oppositely inclined extinction angles.

H. A. M.

C. KLEIN.—*Optische Studien am Leucit.* (*Nachrichten von der k. Gesellschaft der Wissenschaften zu Göttingen.* 1884, p. 421.)

Having shown in a previous paper that Leucite, which is generally regarded as tetragonal, becomes isotropic when heated, the author now pronounces the mineral to be rhombic, and concludes that it crystallised in the cubic system and became rhombic on cooling. It is not tetragonal because (1) twinning takes place on all the dodecahedron faces, and (2) no plane exactly plays the part of the basal plane in the tetragonal system.

Crystals of Leucite may consist either (A) of a single individual with interposed twin lamellæ, or (B) of three interpenetrating individuals so arranged that their basal planes form the cube faces of the compound (and apparently cubic) crystal. In case (A) one of the three cubic sections is characterised by more abundant twin lamellation and weaker double refraction than the other two, and corresponds to the basal plane; in case (B) the three cubic sections are identical.

The results described in the paper are derived from sections carefully cut in *definite* directions. For example—In crystals of the class A *cubic sections* show blurred lamellæ parallel to the cube edges due to twinning on the 8 dodecahedron faces inclined to the section, and sharply defined lamellæ perpendicular to the edges, due to twinning on the 4 dodecahedron faces perpendicular to the section; *octahedral sections* show blurred lamellæ parallel to the octahedron edges due to twinning on the 6 faces inclined to the section, and sharper lamellæ perpendicular to the edges due to twinning on the 6 faces perpendicular to the section; *dodecahedral sections* show blurred lamellæ parallel to the dodecahedron edges due to twinning on the 8 faces inclined to the section, and sharp lamellæ parallel to the shorter diagonal of the dodecahedron face due to twinning on the 2 faces perpendicular to the section (the remaining two faces of the form being parallel to the section).

Icositetrahedral sections show blurred lamellæ in 4 directions due to twinning on the 10 faces inclined, and sharper lamellæ in one direction due to the 2 faces perpendicular, to the section.

Similar sections of crystals belonging to the class B show lamellations which are explained by the same twinning.

If sections are made in a crystal of the first class parallel to three dodecahedral faces in a zone, two of these sections must (if the crystal be rhombic) belong to the dome {201} and one to the prism {110} ; they are found to be distinguished by having their shorter and longer diagonals respectively the axis of greater optical elasticity. All the above facts lead to the conclusion that the mineral possesses rhombic symmetry, though in its geometrical and physical characters very near to the tetragonal or even to the cubic system. It has been by various authors ascribed with great plausibility to each of these three systems, and the author suggests an explanation when he points out that a crystal belonging to the class B will have rhombic, tetragonal, or cubic habit and characters, according as there is a predominance of one, two, or equally of all three of the individuals.

H. A. M.

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ADDRESS TO THE MINERALOGICAL SOCIETY.

By Professor T. G. BONNEY, D.Sc., LL.D., F.R.S., P.G.S., &c.

AT the conclusion of my term of office it is a great pleasure to me to be able to congratulate the Society on the condition of its finances. This, three years since, caused some of us no little anxiety ; now, thanks to the efficient management of our Honorary Secretary, we can look forward to the future with confidence.

A slight diminution in the number of our members is, however, to be regretted, as well as some falling off in the number of papers read at the meetings and in the amount of our publications. It would, no doubt, have been easy to have increased the last by the occasional admission into the Journal (as has been done in some of the earlier volumes) of papers which dealt as much with general geology as with mineralogy, but the Council is of opinion that it will prove ultimately more for the real interest of the Society to risk some temporary reduction in the amount published, and even some arrest of its increase in numbers, in order to maintain and strengthen its distinctive character. There are in

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Britain many Geological Societies, and many publications devoted to that science, none of which would exclude papers containing mineralogical information. But our own is the only Society which by its title is restricted to the study of mineralogy, and to whose Journal the inquirer would naturally turn for information on that branch of Geognosy. It is a great advantage to a student to know that in a particular Journal he is likely to find the best papers on any special subject, and I believe that we shall do well in the future to secure the high character both of our Journal and of the Mineralogical Society, by avoiding any thing which may look like competition with the publications of Geologists.

Last year I ventured to call your attention to an evil—as it seemed to me—too prevalent among mineralogists, that of distinguishing by new names minerals which either are merely varietal or are in some cases actually indefinite. I again recur to it, because I do not see many signs of a change for the better, and because I am more than ever convinced of the mischief which is being done by this habit of species-splitting to the true progress of mineralogy. There is, perhaps, no one of the Natural Sciences which more than it stands in need of a philosophical treatment, or which has progressed so little beyond a system of classification. In the hands of too many students the notation of difference seems the one thing desired. Numbers of minerals are at present in a worse position than the genus *Rubus*, when more than a hundred species in Britain alone were invented for it by some systematic botanists, for even then there was a genus *Rubus*. Now my complaint is that the idea of *genus* has been only very imperfectly admitted into mineralogy. Yet, as I pointed out last year, this idea, viz. that of relationship, is for purposes of scientific progress of higher value than the idea of species, viz. that of distinction. Inductive reasoning, which is the basis of all science, has far too little scope in mineralogy as ordinarily pursued. Indeed it is hardly too much to say that, were it not for crystallography or crystallogogy, as it might be more properly called—a department of applied mathematics—mineralogy would be more appropriately named mineralography—that is to say, it could not really claim to rank among the sciences. I do not forget in thus saying that chemistry forms a part of mineralogy, and necessitates processes

of inductive reasoning ; but, as applied to mineral analysis, this reasoning is not of a high order, so that it is possible for a man to be an excellent practical analyst, and yet neither to have acquired the habit nor to possess the capacity of regarding any question in a truly scientific spirit.

The careful notation of differences, whether these be of form, of chemical composition, or of physical characters, is, of course, valuable ; but their co-ordination, with a view of bringing them into systematic relation and of ascertaining in some sense their cause, is far more valuable. In mineralogy the former process is a familiar one, but the latter is at present comparatively strange to us. The science, in fact, still needs its Darwin.

A first step in the development of mineralogy as a science will be made, in my opinion, by following the example of the biological sciences and adopting a binomial nomenclature. It is true, this is done, though timidly and half-heartedly, by the recognition of groups, such as the garnets, the micas, the feldspars, the pyroxenes, &c.; but I contend for the admission of this as an accepted principle, and for the use in all scientific writings of the name of the genus (or group) as well as of that of the species. It is, perhaps, immaterial whether we adopt the biological practice (which I should prefer) of placing the generic name first and the specific second, or follow that which custom in mineralogy has to some extent sanctioned, and reverse the order; *i.e.* whether we say garnet-melanite or melanite-garnet, mica-biotite or biotite-mica. It may, perhaps, be urged that every one knows that melanite and essonite are both garnets, biotite and phlogopite both micas ; but relationships among rarer minerals are not so readily learnt and retained, and, in any case, I maintain that a system of nomenclature which deliberately excludes relationships is philosophically unsound.

The investigation of the conditions and limits of the genus in mineralogy, I think, cannot fail to lead to most interesting results. Let us take for example that group of bisilicates of lime, magnesia and iron, of which hornblende and augite are leading forms or species—that which is now sometimes called the pyroxene group. I will attempt to sketch out a few only of the questions which will arise in endeavouring to constitute this as a genus. We shall, I sup-

pose, having in view the fact of pleomorphism, admit that chemical composition rather than crystalline form must be the basis of our definition of genus. In this case, then, probably the first definition of the genus which we should suggest would be "a bisilicate of lime, magnesia and iron, in which usually the first two are dominant over the third;" besides this we should admit as possible variations the presence of alumina, sometimes to a considerable amount, or, more rarely, of a small quantity of an alkali. These last rather important chemical differences would suggest the consideration of whether they were sufficiently associated with other characteristics to make them dominant in any minor grouping of the different species, like sub-generic distinctions—a point on which I will not venture to express an opinion; then would arise the important question whether our genus could be extended to include the minerals, which at the present day are sometimes designated the orthorhombic pyroxenes, such as hypersthene, enstatite, bronzite, &c. As these appear to be almost or wholly free from lime they would perhaps require the establishment of a separate genus. Be this as it may, the investigation of the limits which in this case could be conceded to isomorphic replacement would be full of interest. I should hold that if we found a certain chemical variation always produced a change in the crystalline system we might reasonably consider this as cause for a generic separation. Having, then, fixed the limit of our genus "pyroxene" (or whatever it be called), the question of specific limitation will arise. We should have to investigate the marked differences of habit as regards crystalline form, colour, &c., and to determine how far these were related to differences in composition or differences in environment. I will mention two or three questions which have occurred to myself, as examples of those which we should be led to investigate. Why is the augite in lavas generally almost black in colour, while that in crystalline limestones is green? What is the cause of the extraordinary development of a pinacoidal cleavage in diallage? To what is due the actinolitic habit (as I may call it) in certain varieties of hornblende? Is it always indicative of some kind of metamorphic action? Many like questions will arise—in fact I believe that if any skilled mineralogist would undertake the study of the above group of bisilicates, not in the spirit of the species

maker, but in that of the true man of science, he could not fail to add very largely to our knowledge, and to establish principles which would be capable of wider application. Such investigations as those of Foerstner on felspars from Pantellaria, or of Klein on leucite, noticed in the last number of our Magazine, and the suggestive remarks on the minerals of some of the Scotch peridotites and gabbros, by my friend Prof. Judd, published in the current volume of the Geological Society's Journal, appear to me very hopeful in regard to future progress.

Let me, in conclusion, draw attention to a series of investigations which seem likely to become valuable in obtaining answers to questions similar to those mentioned above, but which, I think, are not very generally known. I refer to the synthetic or artificial production of minerals, which are not unfrequent constituents of the earth's crust. Its importance is obvious, because thus the inferences may be tested which are suggested to us by the study of minerals as they occur in nature.

In some cases mixtures of simpler substance have been operated upon; in others, crystalline segregation has been induced in the vitreous products of fusion. In both of these processes the result has been obtained, sometimes by elevation of temperature only, sometimes by the joint action of heat, water and pressure.

With these investigations the names of MM. Daubrée, Fouqué and Lévy are more especially connected, and many of the results are described in the *Géologie Experimentale* of the first, and the *Synthèse des Minéraux et des Roches* of the others. In the experiments of the latter, the materials were, in general, fused by the action of heat alone, while M. Daubrée more commonly produced his results in the 'wet way.' It would occupy too much space did I attempt to enumerate the minerals, known to occur in nature, which have been produced artificially; but, confining myself to silicates only, I may mention the following as of special interest, because they enter into the composition of important rock masses: viz. enstatite, varieties of pyroxene, olivine, leucite, nepheline, the principal species of felspars, some species of garnet, biotite, zircon, sphene, besides other minerals less normally present or belonging to other groups, such as wollastonite, apatite, the spinellids, &c.

Some species also of the igneous rocks have been artificially

produced. These are, according to MM. Lévy and Fouqué, andesites and allied rocks; basalts and other rocks of similar chemical composition; nephelinite; leucitite, leucotephrite, and varieties of peridotite. Some of the experiments also were very suggestive in bringing as their result minerals different from those which had been introduced into the original mixture; for example, after fusion, wernerite crystallised as labradorite; a mixture of wernerite and hornblende produced a rock consisting of labradorite and augite; a mixture of oligoclase and hornblende produced an augitic andesite; a mixture of microcline and biotite resulted in a crystalline mass composed of leucite, olivine, melilite and hæmatite, i.e. a variety of an olivine-leucitite. Other experiments by their negative results seemed to indicate "that natural rocks composed of quartz, orthoclase, biotite, hornblende," were not formed by a simple process of dry fusion. As might be expected, the time during which a high temperature was maintained and the method of cooling brought about important and suggestive results, upon which, however, I need not now enter. By operating at lower temperatures, in sealed tubes, and in the presence of water, Daubrée converted wood into anthracite, and obtained from an ordinary glass crystallised quartz, diopside and some other silicates. In the latter experiment very remarkable changes were produced in the main mass of the glass itself: parts of it became crowded with microliths, some of pyroxene, some probably of a silicate; while other parts were completely occupied by spherulites, or by tufted masses of elongated microliths of quartz. Similar to these are the results of experiments on the action of dry heat on glasses, at temperatures below their fusing-point. Some of these have been described by myself in another address,* but a more exhaustive investigation is being made by Messrs. Rutley and Herman, the results of which have been in part communicated to the Royal Society. In certain cases, when the glass has been kept for a considerable time at a high temperature, its whole mass appears to have been converted into crystallites; and it is especially interesting to find a close relation between the directions of crystal growth and the form of the substance operated

* To the Geological Society, on Feb. 20th, 1885. See *Quarterly Journal G. S.* Vol. xli

on, indicating the intimate connection of its crystallisation with any thing which disturbs its molecular equilibrium. As I have indicated in the address to which reference has been made above the bearing of these experiments upon the formation of crystalline constituents in rock masses, I will not enlarge upon the subject on the present occasion ; but I mention it because it appears to me a very promising field for investigation. The glasses employed in the arts supply us with substances which vary considerably in chemical composition, and can be procured in quantities which renders the determination of their constituents (often not numerous) comparatively easy. The process of devitrification by dry heat does not require either extremely high temperatures or elaborate and expensive apparatus, while crystals are not seldom obtained of sufficient size and in sufficient abundance to render a determination of the resultant minerals not difficult.

There is then, it seems to me, a great field of work, calling for the exercise not only of patient observation but also of close inductive reasoning, open before the mineralogist. Here one and there another is already pressing forward into it, now from the side of crystallogogy, now of chemistry, now of petrology ; hence I venture to predict that in the future mineralogy will occupy a far higher rank than it has done of late among the most exact of the natural sciences. I rejoice to think that I am now giving place to one who is so well qualified to act as a leader in this great work, for which I am disqualified by imperfect knowledge, and from which I am diverted by the attraction of other branches of geognosy. Thus, while thanking the members of the Mineralogical Society most heartily for the undeserved honour which they did me in electing me President, and for their continual kindness during my tenure of office, I congratulate them on having obtained as my successor one who is not only so well qualified in other respects, but also is so vastly my superior in the knowledge of their science.

Notes on Minerals from Cornwall and Devon.

By R. H. SOLLY, F.G.S., Demonstrator in Mineralogy to the University of Cambridge.

Fluor Spar, Holmbush Mine, Callington.

I OBTAINED this summer a most beautiful variety of fluor spar, which was raised from the 145 fathom level of the Holmbush Mine. It is of a transparent azure-blue colour, and shows well marked fluorescent phenomena, though not so strongly as that of Weardale, Cumberland.

Some of the specimens are deep blue in one part and limpid like glass in another; it was found that while the deeply coloured part was strongly fluorescent the limpid part had little or no effect upon the refrangibility of the light passed through it.

The cube planes exhibit well marked rectangular impressions.

Minerals from the Mid-Devon Copper Mine.

There is no record of the minerals to be found at the present time on the burrows of the Mid-Devon Copper Mine, late Belstone Mine, in the parish of Belstone, near Okehampton, and so I thought it would interest the members of the Society if I exhibited and briefly described the minerals I found there this summer.

The mine is situated at the junction of the granite with the millstone grit; the lode, which is of copper pyrites and mispickel, is a flat lode of an ill-defined character, and the ore is richest for copper in the immediate vicinity of the axinite rock. I found the following minerals:—

Garnet, axinite, asbestos, dark green semi-opal, red jasper, copper pyrites, quartz and calcite. The greater portion of these minerals were raised from the 100 fathom level.

Garnet.

This mineral is very abundant, forming large rock masses; some of the crystals are large dodecahedra about $\frac{3}{4}$ of an inch in diameter, of a dull greenish-yellow colour, with very narrow {211} planes.

A few of the crystals exhibit a peculiar structure resembling the mode of growth of the capped quartz crystals from Virtuous Lady Mine, Tavistock. A smaller crystal of a dark-green colour is enveloped by a larger

one more or less altered and lighter coloured, with outer faces parallel to similar faces of the inner crystal. The layer in between the two crystals is soft and brittle, so that the inner crystal can sometimes be removed. Deposited upon the larger crystals are a few smaller dodecahedra of a semi-transparent olive-green colour.

Asbestos.

This mineral is fairly abundant, sometimes verging on actinolite, but more often in tough white masses of the "mountain cork" variety in which the best crystals of axinite are found.

Semi-Opal, Jasper and Hornstone.

I found a few large lumps of dark-green semi-opal, and smaller pieces of red jasper and grey hornstone.

Mispickel.

Some of the crystals of Mispickel are well-defined, with good lustre, elongated in the direction of the *c* axis, and exhibiting the forms *a* {100} *s* {102} *l* {101} *m* {110} *e* {011}.

Copper and Iron Pyrites.

These are met with usually in the massive form mixed together.

Calcite.

In small quantities. Sometimes surrounding the crystals of axinite, whose lustre it has preserved.

Axinite.

Fine large semi-opaque dark-brown crystals of axinite are intimately associated with the garnets; some of the crystals are $1\frac{1}{2}$ inches long, and one inch broad.

The crystals exhibit the Botallack habit, but are less modified. The planes found are *r* {011} *v* {100} largely developed, narrow *x* {111}, rough *c* {1 $\bar{1}$ 1}, small *p* {010} *z* {012} *l* {120} *u* {110} *s* {121}; the two latter planes are striated parallel to their own intersections. A very common aggregation is met with, of polysynthetic crystals of the above habit grown not quite parallel to the *r* plane. This causes the two parallel *p* planes to be as much as 5° or 10° out of the 180°, and the zone *p v* to be largely developed.

The crystals are elongated in a direction nearly parallel to the normal to the plane *c*.

I give here, as an addendum to the above note, a full account of this very interesting mineral, with the view of facilitating the future work of any other investigator.

Thumerstein was the first name given to axinite by Werner, 1788 (*Bergman Journ.* p. 55 and p. 262), from Thum, in Saxony, where it was found. Previous to this date this mineral had been known only as a variety of schorl.

In 1791 Delaméthérie called it yanolite (violet stone), but it was not until 1822 that Haüy published the first crystallographic account of this mineral, which he had previously called axinite.

Literature (Crystallographic).

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| Haüy, | 1822. | Traité de Mineralogie, III. p. 22. |
| Haüy, | 1822. | Traité de Crystallographie, p. 87. |
| Phillips, | 1823. | Elementary Introduc. Mineral. p. 48. |
| Neumann, | 1825. | Poggendorf's Annalen IV. p. 63. |
| Kupffer, | 1826. | Pogg. Ann. Bd. VIII. p. 228. |
| Levy, | 1837. | Descr. d'une Coll. de Min., Vol. II. p. 107. |
| Brooke & Miller, | 1852. | Mineralogy, p. 848. |
| Des Cloizeaux, | 1862. | Manuel de Minéralogie, p. 515. |
| Hessenberg, | 1863. | Mineralogische Notizen, No. V. p. 27. |
| Vom Rath, | 1866. | Poggendorf's Annalen, CXXVIII. pp. 20, 227. |
| Schrauf, | 1870. | Sitzungsberichte der k.k. Akad. Wiss. LXII. Abth. p. 712. |
| Websky, | 1872. | Min. Mitth. Tschermak, Heft. I. p. 1. |
| Hessenberg, | 1873. | Mineralogische Notizen, No. XI. p. 80. |
| Frazier, | 1882. | The American Journal of Science. Vol. XXIV. p. 439. |

(Physical and Chemical).

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| Rose and Riess, | Schriften Akad. Berlin. LIX. p. 375. |
| Rammelsberg, | 1875. Handbuch der Mineralchemie, p. 544. |
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The above list includes all publications relating to axinite which contain original crystallographic, physical and chemical work.

The names of many other works are omitted, which only contain information compiled from earlier sources, or which merely mention a new locality where this mineral has been found.

The four most important and comprehensive works are those by Neumann, Des Cloizeaux, Vom Rath and Schrauf.

The valuable work by Phillips in 1823, with record of six new planes and five doubtful or vicinal faces, is entirely ignored by Neumann, who does not quote his work, and even Miller, in 1852, also omits the face

		Hädy.	Phillips.	Neumann.	Miller.	Des Cloiz.	Vom Rath.	Schrauf.	Discoverer.
v	100	T	K	v	v	g ₁	v	M	Hädy.
p	010	P	M	p	p	m	P	c	"
m	001	M	f ₂	m	m	c ₁	m	m	"
x	111	x	d ₁	x	x	i ₁	x	x	"
c	111			c	c	s	c	Y	Neumann.
n	111	n	c	n	n	e ₁	n	n	Hädy.
q	211			m	q	d	q	q	Neumann.
s	121	s	h	s	s	s	s	s	Hädy.
o	121							o	Schrauf.
d	121						d	d	Vom Rath.
o	112		d ₂	o	o	x	e	o	Phillips.
o	112						d	d	Vom Rath.
i	131		a ₂	o	i	o ₁	i	i	Phillips.
ψ	113						ψ	ψ	Schrauf.
k	221						k	k	Vom Rath.
u	110	u	T	u	u	t	u	u	Hädy.
w	110		k'	w	w	g ₂	w	w	Phillips.
h ₂	9 11 0					h ₂	h ₂	K	Des Cloizeaux.
a	340						a	a	Vom Rath.
h ₂	230					h ₂	h ₂	H	Des Cloizeaux.
β	350						β	β	Vom Rath.
l	120	l		l	l	k'	l	l	Hädy.
h	180						h	h	Vom Rath.
y	101		d ₂	y	y	γ	y	a	Phillips.
b	101						b	b	Vom Rath.
μ	201								Hessenberg.
f	102					β	f	f	Des Cloizeaux.
g	103						g	g	Vom Rath.
r	011	r	P	r	r	p	r	r	Hädy.
e	011		f ₂	r ₁	e	c ₁	e	e	Phillips.
φ	031								Hessenberg.
π	021		f'					π	Schrauf.
c ₂	045					c ₂		L	Phillips.
s	012	s		s		c ₂	s	s	Hädy.
t	231						t	t	Vom Rath.
e	132								Websky.
ρ	231								Schrauf.
η	13 46 11						η	η	Vom Rath.
θ	312						θ	θ	"
ζ	215						ζ	ζ	"
ξ	163						ξ	ξ	Schrauf.
τ	183						τ	τ	"

{045}, merely reproducing in his Mineralogy (Brooke and Miller) Neumann's results in Millerian symbols. The plane f {045}, discovered by Phillips, omitted by Neumann, reproduced by Des Cloizeaux as c , again omitted by Vom Rath, but reinstated by Schrauf as L , is present on some of the crystals in the Cambridge Collection.

The number of definite forms at present observed on axinite are 42—

Haüy	discovered	10
Phillips	"	6
Neumann	"	2
Des Cloizeaux	"	8
Vom Rath	"	12
Schrauf	"	6
Websky	"	1
Hessenberg	"	2
		42

The table on p. 205 gives a complete list of the 42 forms at present established, with the names of their first observers and the letters employed to designate the planes by Haüy, Phillips, Neumann, Miller, Des Cloizeaux, Vom Rath and Schrauf. The form ν {211}, given by Frazier, is omitted, as it is undoubtedly a mistake.

Doubtful Faces.

The following measurements were obtained by Phillips from the five vicinal or doubtful faces, i_1, i_2, i_3, i_4 , in zone pu :—

$$\begin{cases} p i_1 = 0^\circ 40' \\ p i_2 = 5^\circ 20' \\ p i_3 = 37^\circ 32' \\ p i_4 = 41^\circ 50' \end{cases}$$

Also a , 1° from p and $46^\circ 35'$ from r .

Hessenberg, page 28 *Mineral. Not.* V. 1863, describes a doubtful face he calls β (056) on a crystal from Scopi.

Vom Rath, on p. 250 of his Memoir, describes a dull face on a crystal from Botallack, which he calls λ , lying between w and q , and probably truncating the edge between them.

Websky describes five doubtful or vicinal faces lying between p and r —viz. $\pi_\alpha, \pi_\beta, \pi_\gamma, \pi_\delta, \pi_\epsilon$, on crystals from Striegau, in Silesia.

$$\begin{cases} r \pi_\alpha = 20^\circ 46' \\ r \pi_\beta = 19^\circ 25' \\ r \pi_\gamma = 10^\circ 21' \\ r \pi_\delta = 4^\circ 53' \\ r \pi_\epsilon = 4^\circ 9' \end{cases}$$

Elements.

It has appeared best for the practical value of this paper to choose such elements as most nearly approach the mean values of measurements obtained from crystals from different localities, instead of giving different elements for different localities; and these seem to be best obtained from the theoretical angles calculated by Vom Rath. Miller's elements have therefore been discarded, but his mode of projection and the faces he chose for his 100, 010, 001, 111 planes have been retained (see Fig. 1, Pl. V.). Schrauf, desiring to contrast axinite with sphene, has chosen different values for his elements and different axial planes, also a different position for his crystal, but since they agree less closely with the mean values found by other observers, and depict less clearly the habit of the crystal, they have not been adopted. He makes a mistake in his stereographic projection in the zone *Mc*. He places the planes $l, h_1, h_2, \beta, \alpha, v$, in this order instead of $l, \beta, h_1, \alpha, h_2, u$; and also transforms Vom Rath's indices of the plane h_2 into 779 instead of 14 14 7.

$$\begin{aligned} 011 : 010 &= 45^\circ 15' \\ 001 : 011 &= 44^\circ 40\frac{1}{2}' \\ 101 : 001 &= 56^\circ 58' \\ 100 : 101 &= 40^\circ 52' \\ 100 : 010 &= 77^\circ 15\frac{1}{2}' \end{aligned}$$

Combinations.

The following is a list of the faces which have been found on crystals from the undermentioned localities. The usual prominent faces are printed in thicker type.

Botallack.— $p \phi r z m, l u v w, s x y c, g \mu b, o n, d$. (Vom Rath, Fig. 17.) See Fig. 8, Pl. V.

Belstone.— $p r x, l o v, s, c$.

Dauphiné.— $e p r z m, l \beta h_2 u a v w, i s x y, f, o, g, k, d, \xi, t$. (Vom Rath, Fig. 18.) See Fig. 4, Pl. V.

Baveno, and Oisans.— $p r, l u v x n$. (Strüver.)

Santa Maria.— $p r, u v w, s x y, o$.

Striegau.— $p \pi r m, l u w, s x, f$. (Websky, Fig. 3B.) See Fig. 8, Pl. V.

Scopi.— $p r m, \beta u v w, s x y, t, n$. (Hessenberg.)

Hartz.— $p r, l u v, s x, c$.

Poloma.— $e p \phi r z m, l u v w, s y c \sigma, o n, \rho, t, d$. (Schrauf, Fig. 19.) See Fig. 6, Pl. V.

Lake Onega.— $e p \pi r m, h l u v, s x y, \xi, \tau$. (Schrauf, Fig. 20.) See Fig. 7, Pl. V.

Nordmarken.— $p r m, l u, s y, f, g$.

Filipstad, Wermland.— $p r m, s u$.

Kongsberg.— $p r z m, l u v, s x y, o, n d.$ (Vom Rath.)

Pyrenees.— $p r, l u v, s x.$ (Schrauf.)

Bethlehem.— $e p \phi r s m, l u v w, s x y c \sigma, d m b, \delta o.$ (Frazier, Fig. 2.)

See Fig. 5, Pl. V.

The following is a list of calculated angles :—

$ep = 45^{\circ}19'$	$pi = 24^{\circ}33'$	$ry = 58^{\circ}45'$	$mg = 24^{\circ}12'$
$p\phi = 18^{\circ}36'$	$is = 8^{\circ}45'$	$yg = 27^{\circ}39'$	$gf = 10^{\circ}37'$
$\phi\pi = 8^{\circ}11'$	$sz = 16^{\circ}7'$	$qw = 29^{\circ}18'$	$fy = 22^{\circ}9'$
$\pi\tau = 18^{\circ}27'$	$xy = 29^{\circ}48'$	$wt = 20^{\circ}1'$	$yv = 40^{\circ}52'$
$rcs = 6^{\circ}19'$	$yc = 36^{\circ}11'$	$td = 11^{\circ}46'$	$v\mu = 20^{\circ}9'$
$cs s = 12^{\circ}2'$	$os = 23^{\circ}27'$	$d\epsilon = 22^{\circ}6'$	$\mu b = 14^{\circ}48'$
$sm = 26^{\circ}21'$	$op' = 41^{\circ}9'$	$er' = 10^{\circ}26'$	$bm' = 47^{\circ}13'$
$mc' = 44^{\circ}45'$			
$eh = 46^{\circ}13'$	$pf = 82^{\circ}31'$	$rf = 47^{\circ}40'$	$m\psi = 26^{\circ}47'$
$hs = 22^{\circ}$	$fo = 25^{\circ}6'$	$fc = 39^{\circ}14'$	$\psi o = 11^{\circ}13'$
$sg = 57^{\circ}29'$	$op' = 72^{\circ}16'$	$cp = 23^{\circ}37'$	$oc = 21^{\circ}57'$
$ge' = 54^{\circ}18'$		$pr' = 69^{\circ}29'$	$cw = 37^{\circ}5'$
$el = 48^{\circ}25'$	$\phi s = 30^{\circ}58'$		$wk = 18^{\circ}20'$
$lx = 32^{\circ}30'$	$sw = 86^{\circ}48'$	$rg = 44^{\circ}32'$	$kn = 14^{\circ}9'$
$xf = 38^{\circ}40'$	$w\eta = 39^{\circ}28'$	$go = 25^{\circ}14'$	$nd = 13^{\circ}48'$
$fx = 13^{\circ}23'$	$\eta\phi' = 22^{\circ}46'$	$os = 35^{\circ}52'$	$dm' = 36^{\circ}41'$
$\zeta\psi = 9^{\circ}3'$		$oe = 55^{\circ}9'$	
$\psi e' = 37^{\circ}59'$		$er' = 19^{\circ}11'$	
$eu = 55^{\circ}9'$	$\pi i = 39^{\circ}52'$		$ms = 68^{\circ}36'$
$uy = 49^{\circ}40'$	$iu = 19^{\circ}44'$		$od = 50^{\circ}40'$
$yo = 35^{\circ}58'$	$\mu\mu = 37^{\circ}17'$		$dm' = 60^{\circ}44'$
$oe' = 39^{\circ}13'$	$\mu n = 38^{\circ}6'$	$zs = 49^{\circ}52'$	
	$ns = 28^{\circ}2'$	$sh_s = 23^{\circ}14'$	$bc = 97^{\circ}19'$
	$e\pi' = 22^{\circ}59'$	$h_s = 106^{\circ}54'$	$do = 78^{\circ}18'$
$ev = 75^{\circ}24'$			$dh = 38^{\circ}49'$
$vq = 31^{\circ}39'$	$\pi s = 27^{\circ}34'$	$sx = 48^{\circ}11'$	$\beta o = 22^{\circ}26'$
$qc = 24^{\circ}6'$	$sv = 54^{\circ}17'$	$zb = 74^{\circ}15'$	$cu = 80^{\circ}26'$
$ce' = 48^{\circ}51'$	$vk = 44^{\circ}45'$	$bs' = 57^{\circ}34'$	$\delta e = 58^{\circ}51'$
$eb = 53^{\circ}9'$	$kd = 21^{\circ}13'$		$\eta n = 41^{\circ}3'$
$bd = 14^{\circ}38'$	$d\epsilon = 10^{\circ}51'$	$sv = 88^{\circ}36'$	$\eta s = 132^{\circ}40'$
$\theta w = 37^{\circ}12'$	$\xi\pi' = 21^{\circ}20'$	$v\theta = 27^{\circ}39'$	$\eta v = 80^{\circ}2'$
$w\rho = 22^{\circ}48'$		$\theta\delta = 30^{\circ}32'$	$\eta x = 119^{\circ}$
$\rho\sigma = 14^{\circ}15'$	$\pi x = 39^{\circ}35'$	$\delta s' = 33^{\circ}13'$	$fs = 52^{\circ}19'$
$\sigma e' = 37^{\circ}54'$	$xw = 80^{\circ}9'$		$fx = 37^{\circ}36'$
$pb = 80^{\circ}39'$	$w\pi' = 60^{\circ}20'$	$sy = 55^{\circ}9'$	$gp = 84^{\circ}42'$
$bn = 31^{\circ}55'$		$gn = 82^{\circ}36'$	$gw = 79^{\circ}12'$
$nd = 22^{\circ}19'$	$ri = 36^{\circ}29'$	$ns' = 42^{\circ}15'$	$gx = 45^{\circ}50'$
$dp' = 45^{\circ}7'$	$il = 18^{\circ}54'$		$ls = 70^{\circ}49'$
$pm = 78^{\circ}40'$	$lr' = 124^{\circ}37'$	$sg = 30^{\circ}54'$	$nq = 57^{\circ}10'$
$\mu k = 38^{\circ}$		$gc = 44^{\circ}6'$	$ns = 77^{\circ}58'$
$kt = 13^{\circ}49'$	$rs = 36^{\circ}25'$	$cd = 63^{\circ}37'$	$os = 76^{\circ}43'$
$tp' = 49^{\circ}31'$	$su = 27^{\circ}57'$	$dz' = 41^{\circ}21'$	$ov = 70^{\circ}3'$
$ph = 21^{\circ}1'$	$ub = 47^{\circ}14'$		$ox = 61^{\circ}51'$
$hl = 7^{\circ}54'$	$\delta\delta = 30^{\circ}13'$	$ms = 72^{\circ}12'$	$oz = 55^{\circ}12'$
$\beta s = 3^{\circ}58'$	$\delta r' = 38^{\circ}11'$	$sl = 21^{\circ}37'$	$qs = 67^{\circ}56'$
$\beta h_s = 2^{\circ}23'$		$lm' = 86^{\circ}11'$	$qx = 52^{\circ}58'$
$h_a = 2^{\circ}41'$	$rx = 40^{\circ}47'$	$mx = 65^{\circ}1'$	$st = 69^{\circ}35'$
$ah\beta = 2^{\circ}8'$	$xv = 45^{\circ}58'$	$xu = 30^{\circ}38'$	$rp = 23^{\circ}59'$
$h\beta u = 4^{\circ}24'$	$vn = 49^{\circ}32'$		$rr = 24^{\circ}9'$
$uv = 32^{\circ}47'$	$nr' = 43^{\circ}48'$	$um' = 84^{\circ}26'$	$ry = 75^{\circ}10'$
$ew = 42^{\circ}15'$			$\xi u = 64^{\circ}27'$
$wp' = 60^{\circ}29'$			$\xi b = 75^{\circ}38'$
			$\mu q = 47^{\circ}46'$
			$\mu r = 101^{\circ}15'$

The faces in the zone pv are often deeply striated parallel to the intersection of l and u . The faces in the zone pz are channelled and striated parallel to the intersections of the planes p and r . The face p often bears crossed striations at an angle of $77^{\circ}8'$ and parallel to the edge rx and an . All the faces are more or less rounded.

The face c is often dull, and v is sometimes rough. The crystals from Botallack and Belstone are grown nearly parallel to the plane r , and generally elongated in the direction of the normal to c .

Cleavage; m , v and w fair, r indistinct and interrupted, traces along p and y . Fracture; conchoidal to uneven. Brittle. Transparent to translucent on the edges. Lustre; highly vitreous.

Colour; clove-brown of various shades, inclining to plum-blue to pearl grey. It exhibits trichroism. On looking through a crystal in the direction of either optic axis, a dark violet stripe is seen, interrupted at the point occupied by the axis (Miller).

The acute bisectrix is negative, and normal to the plane α . The planes of the red and the green axes appear to be orientated nearly identically like those of the mean. The dispersion, scarcely perceptible in oil, is on the contrary very strong in air. $\rho < \nu$.

$2H$ ranges between $82^{\circ}15'$ and $84^{\circ}50'$

$2E$ „ „ $148^{\circ}58'$ and $172^{\circ}10'$

(Des Cloizeaux.)

Hardness; 6.5 to 7. S. G.; 3.29 to 3.30. Crystals from Oisans, analysed by Rammelsberg before calcination, had a density of 3.295, which was reduced after fusion to 2.812. Acquires vitreous electricity by friction. Pyro-electric, the faces n contain the antilogous poles and the angles uxp and $u'x'p'$ the analogous poles (Riess and G. Rose). (See Fig. 2, Pl. V.)

Before the blowpipe intumesces and fuses easily to a dark-green glass. With fluor spar and bi-sulphate of potash imparts a green colour to the flame. Hardly acted on by acids. After fusion gelatinises with H Cl.

The following analyses and remarks on the chemical composition are by Rammelsberg—

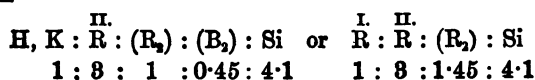
1. Oisans, Dauphiné.
2. Treseburg, Harz.
3. Berkutzkaja Gora, near Miask.

	1.	2.	3.
	<i>a.</i>	<i>b.</i>	
Silica	44.57	48.46	48.73
Boracic Acid	4.50	5.61	—
Alumina	16.87	16.88	15.66
Sesquiox. of Iron	9.67	2.80	11.94
Protox. of Iron	—	6.78	—
Protox. of Mangan.	2.62	2.62	1.87
Lime	20.19	20.19	18.90
Magnesia	1.78	1.78	1.77
Potash	0.11	0.11	—
Water	—	1.45	—
	99.76	101.08	98.87

Rammelsberg considers the water present as water of constitution.

Nos. 2 and 8 have not been examined with regard to the protoxide of iron and the water.

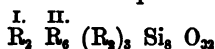
In 1 b :—



that is to say—



If one assumes that axinite in reality contains nearly 2 per cent. of water (its determination being very difficult on account of the contemporaneous change of the protoxide of iron into sesquioxide), it is a uni-silicate.



in which R contains very little K; R = Mg, Mn, 2 Fe, 8 Ca; (R₂) = (B₂) and 2 (Al₂).

The calculated quantity of boracic acid is 6 per cent. (Rammelsberg.)

Axinite occurs in attached crystals or small masses, sometimes fibrous, usually in veins or beds in granite, gneiss, mica and hornblende schists, clay-slate, diorite and diabase. Commonly associated with quartz, albite, orthoclase, epidote, garnet, asbestos, prehnite, tourmaline, &c.

Localities.

ENGLAND—*Cornwall*.—In dark clove-brown crystals, sometimes 1½ inches across, at Botallack Rocks, Roscommon Cliff, Trewellard Cliffs, and Wheal Cock, St. Just; in granite associated with asbestos, epidote, garnet and apatite.

In light grey violet crystals at Boscawen Cliffs, St. Buryan and Lamorna Cove, with epidote, quartz and schorl.

Also at Carharrack, St. Day; Camborne Vean, Camborne; St. Columb;

Trevascus Mine, Gwinear; Wheal Crofty, East Illogan; Lizard; Marazion, Penzance, and in indurated clay-slate at Löstwithiel.

Devonshire.—In dark clove-brown crystals similar to the Botallack ones at Mid-Devon Consols Mine, Belstone, with asbestos, garnet and calcite, also at Sticklepath, Okehampton, Brent Tor, Tavistock.

France.—Most beautiful crystals of a translucent violet-brown colour, sometimes 2 inches across, from Saint Christophe, Oisans, Département de l'Isère, associated with albite, prehnite, quartz and chlorite; at Montanvert, Savoy, and also *Italy*, Baveno.

Switzerland.—At Berg Sella, Saint Gothard; and also at Scopi, near Santa-Maria, Medelser Thal, the Cantons Grisons and Uri.

Germany.—Saxony, Thum, near Ehrenfriedersdorf, with mispickel, blende, pyrrhotine and quartz, also at Schneeberg, Schwarzenberg, Grünstädtel.

In well-developed crystals, from 2 to 10 mm. across, on orthoclase with albite, epidote, quartz and stilbite at Striegau, Silesia, (Websky), Hartz, near Heinrichsburg in Selkethal, Falkenstein, Taunus, Treseburg, Bodethal; with asbestos and prehnite, Wormke, near Schierke; with prehnite on greenstone, Samson Mine, Andreasberg.

In small violet-blue crystals with harmotome and epidote at Bergmannstrots.

Austria.—In dark-brown opaque crystals not strongly lustrous, with calcite, apatite, gold, copper pyrites and malachite, on green hornblende schist, at Poloma, near Betler, Hungary (Schrauf), and at Wallamühle, near Röschitz, Moravia; and Gömörer, Hungary; Monzoni, Tyrol.

Russia.—In dark reddish-brown crystals (habit between that of Botallack and Poloma), in amygdaloidal cavities, on Wolf Island, Onega Lake; also at Berkutzkaja Gora, near Miask, Urals.

Sweden.—Similar to Dauphiné crystals with yellow garnet and idocrase at Phipsburg; also with magnetic iron at Nordmark, and Grundsjö Mine, near Filipstad, Wermland.

Norway.—Small crystals with black mica, quartz and native silver in a white laminated calcareous rock, at King Louis Mine, Kongsberg; also with felspar and epidote at Arendal.

Spain.—Upon a gangue of quartz at Mount Ereslids, near Baréges, Pyrenees, and also at Arbizon, Hautes Pyrenees.

United States.—In small colourless to pale brown crystals, sometimes highly brilliant, with asbestos and hornblende, near Bethlehem, Northampton County, Pennsylvania (Frazier); also at Wales, Maine; and Cold Spring, New York.

South America.—With smaltine and grey cobalt at La Bintre Mine, Coquimbo, Chili.

Note on Dr. Mackenzie's Paper read at the June Meeting.

THE attention of the Editing Committee having been called to the apparent identity of a paper by Dr. G. S. Mackenzie "On an Occurrence of rare Minerals from Utah," with one by Dr. Hillebrand "On an Association of rare Minerals from Utah," the Committee have communicated with Dr. Mackenzie, and have received from him the following letter:—

Craig Lee, near Dundee,
28th November, 1885.

Dear Sir,

In view of the appearance of an article by me in the August number of this Journal entitled "On an Occurrence of rare Minerals from Utah," I beg to state that the credit of the investigation of these minerals is due to Dr. Hillebrand and Mr. Whitman Cross, of the U.S. Geological Survey, Denver, Colo., and, although I have made independent determinations of several of the constituents of these minerals subsequently to them, I exceedingly regret the appearance of the paper in print without due notice having been taken and prominence given to the papers of Dr. Hillebrand and Mr. Cross on this subject in the "Proceedings of the Colorado Scientific Society."

I am, &c.,

(Signed) GEORGE S. MACKENZIE.

R. H. Scott, Esq.,

Secretary of the Mineralogical Society.

Some Results of the Crystallographic Study of Danburite.

By DR. MAX SCHUSTER, of Vienna.

[Communicated by the President.]

[Read October 20th.]

EVERY student of crystals is aware how frequently they fall short of the ideal perfection which theory ascribes to them. With regard to the development of the simple forms, the irregularities are most prominent on the crystals which are subject to certain laws of symmetry. In consequence of the differences of size presented on the same crystal by planes belonging to the same form, the most manifold distortions ensue, resulting at one time in the imitation of forms of a lower degree of symmetry, at another in the complete absence of symmetry. Moreover, as long as the faces constituting the distorted form remain the same, *i.e.* as long as the cause of the distortion is without influence on the development of the combination, so long will the angles of inclination of the circumscribing elements of the individual remain the same, and thus the degree of symmetry can be determined by measurement of the crystal notwithstanding the distortion. This is generally the case, and is characterised as the constancy of the angles of inclination. Exceptions to this law will be alluded to further on.

The physical state of the faces themselves may cause great difficulty in the exact determination of the angles of inclination, for the faces are rarely plane and smooth, being as a rule either curved, or plane but dull, or finally, even when good reflectors, are reticulated or broken up into a number of distinct fields. Unorganised bodies naturally bounded by curved faces can scarcely lay claim to the designation of crystals, but are rather, at most, to be characterised as crystalline individuals, when endowed with a definite homogeneous internal structure. On crystals with plane but dull faces, one may conceive that the outermost molecules of the planes which constitute the boundary surface are homogeneously distributed, though they are not present in sufficient number to correspond with the internal network. Finally, when the faces of a crystal are smooth and bright, but appear broken up into several fields, the following cases may be distinguished:—either the molecules in the different fields are differently arranged towards one another—a point which a simple optical

examination will decide—and the crystal is then only apparently homogeneous, but is in reality a group built up of subordinate individuals in almost parallel position, or in twinned juxtaposition, a case that occurs more frequently in mimetic crystals. Or, again, it is found that all the fields can be referred as bounding elements to one and the same crystallographic individual.

It appears to be an essential character of crystals that they are bounded by a limited number of faces which are parallel to internal molecular planes, more particularly to such planes as may be said to possess the greatest molecular density; the occurrence, therefore, of faces with highly complex indices strikes the observer as being abnormal, and the question arises whether such faces are subject to the same laws, and are as characteristic of the substance on which they occur, as the simple typical faces which they replace.

Whilst engaged upon the crystallographic investigation of the mineral danburite, recently found at Mount Scopi, in Switzerland, the author was in a position to study such elementary planes very completely, and with some unexpected results, which have been given in detail in a paper published elsewhere.*

Among the faces with complex indices, in addition to those which appear as occasional and local developments, and which, as a rule, belong to that class of secondary planes known as "vicinal" planes, others were observed which are characterised by the peculiarity that they almost coincide with the simple typical faces in conjunction with which they are found; so much so, that the inclination frequently amounts to only a few minutes of arc. These faces have a real and probably a genetic relationship to the principal faces.

At present it is desired to draw attention to two of the most marked characteristics of these planes, for which the designation of "transitional faces" has been proposed.

That these planes are genuine, although they often almost defy detection and observation, is proved by the fact that they in the great majority of cases lie in zones well defined by typical planes, and that they occupy in these zones definite positions recurring in many different crystals; further, they frequently appear in exactly the number and distribution corresponding with the symmetrical disposition of those primary faces to which they stand in the relation of vicinal planes.

These faces are, however, in their occurrence much more variable than

* *Tschermak's mineralogische und petrographische Mittheilungen*, Vol. V. p. 397, and Vol. VI. p. 301.

are the faces with simpler indices ; and it is a remarkable fact that they are much more susceptible to the influences which give rise to distortion. Whilst planes with simple indices are either diminished or increased in size by distortion, without being actually obliterated, it frequently happens that under such circumstances existing "transitional faces" are replaced by new ones, of which the disposition may be proved to correspond with the irregular development of the form.

This fact may become exceedingly valuable for the study of the phenomena of crystal-growth, for it affords a means of recognising, not only the exact part of the growing crystal where a disturbance in the uniform development commenced, but also of gaining a clue to the measurable amount of the divergence.

More remarkable yet are the numerical relations between the indices of the various transitional planes and the corresponding simple faces. Such relations are the simplest in the case of pinakoids, and can be briefly expressed thus : the intercepts of the vicinal faces on the axes lying in any pinakoid appear as multiples of a definite factor (which is the same for all the parametral axes) in such a manner that all the indices of the transitional faces in question would be simple, if only the factor were made equal to unity.

It was fully demonstrated in the paper quoted above, that the same factor is similarly related to the indices of transitional faces which appear in conjunction with prismatic and pyramidal faces, though the relationship cannot be expressed so simply as above. As this factor is the same for all the principal planes, without exception, we are led to infer that it represents a particular state of the fluid which surrounded the crystal during the growth of the vicinal faces.

The further circumstance that such planes of highly complex indices resolve into those of simple indices upon the elimination of this factor, seems to indicate that such simple planes at any rate tend to be present.

It would appear, therefore, that the transitional faces, in the case of danburite, spring from the same cause as the inequality in the development of faces of a form. They would thus have to be regarded as the result of the action of two sets of forces ; one acting in connection with the arrival of newly deposited molecules and their state, the other emanating from and connected with the so far completed faces of the crystal ; in other words, these planes are induced by the tendency towards the formation of a new plane over one already completed.

It would be out of place to enter further, on this occasion, upon the subject of the paper already quoted, viz. the deduction, discussion, and

closer confirmation of the above theorems, and the theoretical and practical results which would seem to accrue for the crystallographer. The object of this note will have been fulfilled if the author has succeeded in attracting the attention of students to these remarkable elementary faces, and has convinced them that the study of such subordinate features is not as hopeless as might at first sight appear; but that a prospect is opened up that these complicated features (which to a German *savant* seemed so wonderful that he compared them with those of the living plant) may yet be made amenable to mathematical laws which doubtless underlie them.

INDEX TO MINERALOGICAL PAPERS, &c. 1884.

By H. A. MIERS, M.A.

- AFRICA.** v. Copper Ores.
- ALASKA.** Arzruni. Jahresb. Schles. Ges. 1883, p. 162. *Minerals of.*
- ALBERTITE.** W. Morrison. Min. Mag. vi. p. 101. *Ross-shire.*
- ALBITE.** R. Robertson. Chem. News, 1. p. 208. *Amelia Co. Chem.*
J. Bachinger. Min. Mitth. vi. p. 40. *Fuchs.*
v. Auburn.
- ALLAKTITE.** A. Sjögren. Öfv. Vet. Ak. Förh. 3, p. 29. *New Min.*
- ALLANITE.** E. Dana. Am. J. Sc. xxvii. p. 479. *Cryst. and Zs. K. ix.*
p. 283.
W. Clarke and T. Chatard. Am. J. Sc. xxviii. p. 21. *Chem.*
- ALLEMONTITE.** H. Laspeyres. Zs. K. ix. p. 192. *Valentinite pseud. after.*
- ALUNOGEN.** W. Clarke and T. Chatard. Am. J. Sc. xxviii. p. 24. *Chem.*
- AMALGAM.** F. Sandberger. N. J. (1), p. 191. *Friedrichs-segen.*
- AMAZON-STONE.** C. Page. Chem. News, 1. p. 208. *Amelia Co. Chem.*
- AMPHIBOLE-ANTHO-
PHYLLITE.** } V. Zepharovich. Lotos. xxxiii. p. 40. *Tirol.*
- ANALCIME.** Wada. Ber. Ges. Nat. Fr. Berl. p. 85. *Japan.*
C. Klein. N. J. (1), p. 250. *Table Mountain. Cryst.*
- ANATASE.** A. Schrauf. Zs. K. ix. p. 465. *Cryst. Therm.*
O. Lüdecke. Zs. Naturwiss. Halle, lviii. p. 82. *Brand.*
G. Seligmann. Ber. Nied. Ges. Bonn. p. 5. *Binnenthal.*
and Verh. Nat. Ver. Rheinl. Corr. Bl. p. 95.
- ANATASE & BROOKITE.** K. Kroustchoff. Bull. Soc. Min. vii. p. 337. *Beucha.*
- ANDALUSITE.** G. Kunz. Am. J. Sc. xxvii. p. 305. *Maine.*
L. Grünhut. Zs. K. ix. p. 113. *Cryst.*
F. Gonnard. Bull. Soc. Min. vii. p. 207. *Fores.*
- ANDESINE.** A. Descloizeaux. Bull. Soc. Min. vii. p. 249. *Opt.*
- ANGLESITE.** V. Zepharovich. Lotos. xxxiii. p. 87. *Pseud. after Galena.*
A. Schmidt. Term. Füz. vii. pp. 84, 133. *Pelsöcz-Ardó.*
Cryst.
A. Franzénau. Term. Füz. viii. pp. 77, 119. *Cryst.*
T. Liweh. Zs. K. ix. p. 501. *Badenweiler. Cryst.*
S. Newberry. Am. J. Sc. xxviii. p. 122. *Nevada.*
M. Ossent. Zs. K. ix. p. 563. *Minerals of.*
v. Amphibole.
- ANNABERGITE.** O. Mügge. N. J. (2), p. 40. *Cryst.*
- ANNIVIERSTHAL.** A. Vivier. C. R. xcix. p. 709. *Chem.*
- ANTHOPHYLLITE.** A. Ditte. C. R. xcix. pp. 792, 967. *Art.*
- ANTIMONY.** G. Rowan. Chem. News, 1. p. 208. *Amelia Co. Chem.*
- APATITE.** C. Blas. Bull. Ac. Belg. viii. p. 185. *Chem.*
J. Clouet. Ass. Fr. 1883, p. 435. *Min. &c.*

- APATITE.** C. Hintze. Zs. K. ix. p. 290. *Striegau.*
Wada. Ber. Ges. Nat. Fr. Berl. p. 81. *Japan.*
F. Gonnard. Bull. Soc. Min. vii. p. 65. *Haute Loire.*
C. Doelter. N. J. (2), p. 220. *Therm. Opt.*
E. Dana. Am. J. Sc. xxvii. p. 480. *Cryst. and Zs. K. ix.*
p. 284.
v. Stoneham. Auburn.
- APOPHYLLITE.** Wada. Ber. Ges. Nat. Fr. Berl. p. 84. *Japan.*
O. Mügge. N. J. (1), p. 59. *Hardness, &c.*
C. Klein. N. J. (1), p. 253. *Table Mountain. Cryst.*
v. Lasaulx. Ber. Nied. Ges. Bonn. p. 99. *Finkenberg.*
- ARAGONITE.** C. Klein. N. J. (2), p. 49. *Opt.*
- ARGENTINE REPUBLIC.** G. Lallemant. An. Soc. Arg. xvii. p. 49, xviii. p. 193.
Minerals of.
- ASTROPHYLLITE.** J. Lorenzen. Zs. K. ix. p. 253. *Kangerdluarsuk; and Öfv.*
Vet. Ak. Förh. 2, p. 116.
- AUBURN, MAINE.** G. Kunz. Am. J. Sc. xxvii. p. 303. *Minerals of.*
- AUGITE.** C. Dölter and E. Hussak. N. J. (1), p. 19. *Melting*
Products, &c.
P. Mann. N. J. (2), p. 172. *Chem.*
v. Stoneham.
- AUTUNITE.** v. Stoneham.
- AVALITE.** S. Losanitsch. Ber. Chem. Ges. xvii. p. 1774. *New Min. Chem.*
- BARYTES.** A. Arzruni. Zs. K. ix. p. 74. *Bolivia.*
F. Hauer. Verh. Geol. Reichs. p. 387. *Carpathia. Losoncs.*
F. Sansoni. Rendic. Ist. Lomb. xvii. p. 156. *Vernasca.*
v. Lasaulx. Ber. Nied. Ges. Bonn. p. 170. *Mittelager. Cryst.*
B. Kosmann. B. H. Ztg. xliii. pp. 199, 210.
V. Zepharovich. Lotos. xxxiii. p. 41. *Quartz pseud. after.*
D. Fényes. Term. Füz. vii. pp. 288, 321. *Pesey. Cryst.*
Leuze. Jahresh. Ver. Würt. xl. p. 56. *Württemberg.*
A. Lacroix. Bull. Soc. Min. vii. p. 174. *Chiseuil.*
- BAUXITE.** J. Lang. Ber. Chem. Ges. xvii. p. 2892. *Langsdorf. Chem.*
- BERYL.** Wada. Ber. Ges. Nat. Fr. Berl. p. 84. *Japan.*
W. Clarke and T. Chatard. Am. J. Sc. xxviii. p. 25. *Wash-*
ington.
S. Penfield. Am. J. Sc. xxviii. p. 25. *Chem.*
C. Dölter. N. J. (2), p. 221. *Therm. Opt.*
v. Stoneham.
- BERZELIITE.** L. Igelström. Bull. Soc. Min. vii. p. 27. *Chem.*
E. Bertrand. Bull. Soc. Min. vii. p. 31. *Opt.*
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- BINDHEIMITE.** W. Billebrand. Proc. Col. Sc. Soc. i. p. 119. *Nevada. Chem.*
- BIOTITE.** v. Stoneham.
- BISMUTH.** A. Arzruni. Zs. K. ix. p. 75. *Bolivia.*
H. Foullon. Verh. Geol. Reichs. p. 147. *Tasmania.*
S. Peckham. Am. J. Sc. xxviii. p. 105. *Origin of.*
- BITUMENS.** C. Tichborne. Chem. News, l. p. 23. *Argentiferous.*
- BLENDE.**

- BORACITE.** C. Klein. N. J. (1), p. 235. *Cryst.*
K. Mack. Pogg. xxi. p. 410. *Pyro-el.*
- BORATES.** C. Rammelsberg. N. J. (2), p. 158. *Chem.*
- BORONATRO-CALCITE.** C. Rammelsberg. N. J. (2), p. 158. *Chem.*
- BOSNIA.** F. Hauer. Geol. Reichs. xxxiv. p. 751. *Minerals of.*
- BOTRYOGEN.** J. Blasas. Ber. Ak. Wien. lxxxviii. (1), p. 1121. *Mon.*
- BOURNONITE.** H. Miers. Min. Mag. vi. p. 59. *Cryst.*
- BRÖGGERITE.** C. Blomstrand. Ann. Chim. Phys. iv. p. 129. *Chem. New Name.*
- BRONZITE.** H. Roscoe. Chem. News, 1. p. 244. *Kimberley. Chem.*
- BROOKITE.** V. Zapharovich. Zs. K. viii. p. 577. *Tyrol. Cryst. Opt.*
A. Schrauf. Zs. K. ix. p. 444. *Cryst. Therm. &c.*
v. Anatase.
- BRUCITE.** A. Descloizeaux. Bull. Soc. Min. vii. p. 86. *Art.*
O. Mügge. N. J. (1), p. 57. *Hardness, &c.*
C. Dölter. N. J. (2), p. 221. *Therm. Opt.*
- BURATITE.** A. Lacroix. Bull. Soc. Min. vii. p. 461. *Beaujolais.*
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MONT CATINI. v. Manganese Minerals.
MORAVIA. J. Bachinger. Min. Mitth. vi. p. 49. *Fuchs.*
MUSCOVITE. J. Meehan. Science, iv. p. 368. *Philadelphia.*
 v. Stoneham.

NATROLITE. E. Palla. Zs. K. ix. p. 387. *Cryst.*
NEPHELINE. C. Dölter. Zs. K. ix. p. 321. *Art.*
NEPHRITE. H. Fischer. N. J. (2), p. 214. *S. America.*
 H. Traube. N. J. (2), p. 412. *Jordansmühl.*
NEWFOUNDLAND. M. Wadsworth. Am. J. Sc. xxviii. p. 94. *Ore Deposits.*
NEW MINERAL. E. Foster. Proc. Col. Sc. Soc. i. p. 73. *Sulphobismuthite of Silver.*
 W. Hillebrand. Am. J. Sc. xxvii. p. 355. *Sulphobismuthite of Copper and Silver; and Proc. Col. Sc. Soc. i. p. 53.*
NEW MINERALS. v. Allakite, Avalite, Bröggerite, Colemanite, Euchlorite, Goyazite, Hämafibrate, Hämatolite, Hillangsite, Magnesia-Iron Sulphate, Manganostibiite, Pinnoite, Polyolithionite, Rinkite, Utahite, Xantho-arsenite.
 S. Newberry. Am. J. Sc. xxviii. p. 122. *Nevada.*
 V. Zepharovich. Lotos. xxxiii. p. 42. *Moravicza.*

OBERSCHLESIEH. Althaus. Jahresb. Schles. Ges. 1883, p. 136. *Minerals of.*
 A. Arzruni. Jahresb. Schles. Ges. 1883, p. 161. *Minerals of.*
 B. Kosmann. Jahresb. Schles. Ges. 1883, p. 145. *Min.; and*
 B. H. Ztg. xliii. pp. 198, 209.
OILS. A. Carnot. O. R. xcix. p. 154. *Min.*
OLIGOCASE. A. Descloizeaux. Bull. Soc. Min. vii. p. 249. *Opt.*
OLIVENITE. W. Hillebrand. Proc. Col. Sc. Soc. i. p. 113. *Utah. Chem.*
OLIVINE. C. Dölter and E. Hussak. N. J. (1), p. 26. *Melting Products, &c.*
 A. Lacroix. Bull. Soc. Min. vii. p. 172. *Ile Bourbon.*
 B. Scharizer. Jahrb. Geol. Reichs. xxxiv p. 70. *Jan-Mayen.*
 Wada. Ber. Ges. Nat. Fr. Berl. p. 85. *Japan.*
 J. Kloos. N. J. (2), p. 87. *Opt. Cryst. &c.*

- ORTHOCLASE.** A. Cathrein. Zs. K. ix. p. 368. *Valfloriana. Cryst.*
- PARAFFIN.** A. Griffiths. Chem. News, xlix. p. 107. *Servia.*
- PECTOLITE.** W. Clarke and T. Chatard. Am. J. Sc. xxviii. p. 20. *Chem.*
- PELSÜCZ-ÁRDÓ.** A. Schmidt. Term. Füz. vii. pp. 84, 127. *Minerals of.*
- PEROWSKITE.** C. Klein. N. J. (1), p. 245. *Cryst.*
- PETROLEUM.** C. John. Verh. Geol. Reichs. p. 53. *Hungary. Chem.*
Jahrb. Sieb. Karp. Ver. iv. p. 132. *Carpathia.*
- PFALE.** v. Bibliography.
- PHACOLITE.** C. Rammelsberg. Zts. Geol. Ges. xxxvi. p. 236. *Chem.*
- PHILLIPSITE.** C. Rammelsberg. Zts. Geol. Ges. xxxvi. p. 242. *Chem.*
A. Descloizeaux. Bull. Soc. Min. vii. p. 135. *Opt.*
F. Gonard. C. R. xcviii. p. 839. *Loc.*; and Bull. Soc. Min. vii. p. 166.
- PHOSPHATES.** E. Smith. Science, iv. p. 78. *Alabama.*
- PINITE.** C. Reese. Chem. News, 1. p. 209. *Madison Co. Chem.*
- PINNOITE.** H. Staute. Ber. Chem. Ges. xvii. p. 1584. *New Min. Chem.*
- PITCHBLEND.** Blomstrand. C. R. xcviii. p. 816. *Chem.*
- PITTICITE.** F. Sandberger. N. J. (1), p. 77. *Spitzberg.*
- POLYGENESIS.** L. Bomicci. Mem. Ac. Bol. v. p. 3.
- POLYLITHIONITE.** v. Lepidolite.
- PREHNITE.** O. Lüdecke. Zts. Naturwiss. Halle. lvii. p. 678. *Loc.*
A. Taylor. Min. Mag. vi. p. 104. *Edinburgh.*
W. Clarke and T. Chatard. Am. J. Sc. xxviii. p. 24. *Chem.*
G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 95. *Binnenthal.*
W. Hillebrand. Proc. Col. Sc. Soc. i. p. 120. *Chem.*
H. Foullon. Verh. Geol. Reichs. p. 142.
E. Doll. Verh. Geol. Reichs. p. 130.
A. Descloizeaux. Bull. Soc. Min. p. 468. *Bagnoles.*
L. Busatti. Att. Soc. Tosc. vi. p. 21. *Min.*
J. Bachinger. Min. Mitth. vi. p. 52. *Fuchs.*
Wada. Ber. Ges. Nat. Fr. Berl. p. 79. *Japan.*
E. Doll. Verh. Geol. Reichs. p. 130. *Pseud. after Copper Pyrites.*
- PYROSMAILITE.** A. Gorgeu. C. R. xcviii. p. 586. *Chem.*; and Bull. Soc. Min. vii. p. 58.
- PYROXENE.** C. Dölter and E. Hussak. N. J. (1), p. 19. *Melting Products, &c.*
C. Dölter. N. J. (2), p. 51. *Art.*
- PYRHOTITE.** G. Seligmann. Verh. Nat. Ver. Rheinl. Corr. Bl. p. 95. *Cyclopean Is.*
V. Zepharovich. Lotos. xxxiii. p. 38. *Carinthia.*
A. Kennigott. N. J. (1), p. 187. *Brazil.*
- QUARTZ.** A. Cornu. Bull. Soc. Min. vii. p. 56. *Opt.*
A. Gorgeu. Bull. Soc. Min. vii. p. 176. *Art.*; and C. R. xcviii p. 1281.

QUARTZ.

- J. Thonlet. Bull. Soc. Min. vii. p. 182. *Opt. Therm.*
 Nica. Jahresh. Ver. Würt. xl. p. 52. *Tiger's Eye.*
 E. Ketteler. Pogg. xxi. p. 438. *Dispersion of.*
 B. Kolenko. Zs. K. ix. p. 1. *Pyroel.*
 A. Renard. Bull. Ac. Belg. viii. p. 324. *Pseud.*
 A. Renard and C. Klement. Bull. Ac. Belg. viii. p. 530. *Chem.*
 G. v. Rath. Verh. Nat. Ver. Rheinl. p. 290. *N. Carolina Cryst.*
 Wada. Ber. Ges. Nat. Fr. Berl. p. 80. *Japan.*
 A. Becker. Min. Mitth. vi. p. 158. *Spec. Grav.*
 R. Robertson. Chem. News, l. p. 207. *Blue. Chem.*
 P. Groth. Ber. Ak. Münch. p. 1. *Pyroel.*
 C. Dölter and E. Hussak. N. J. (1), p. 40. *Melting Products, &c.*
 V. Zepharovich. Lotos. xxxiii. p. 41. *Lomnitz. Pseud. after Barytes.*
 O. Lüdecke. Zts. Naturwiss. Halle. lvii. p. 73. *Harsgerode.*
 W. Hankel. Ber. Sächsh. Ges. 1883, p. 35. *Thermoel.*
 v. Stoneham. Auburn.

RAMMELSBERGITE.
 RHABDOPHANE.

- F. Sandberger. N. J. (1), p. 70. *Chem.*
 G. Brush and L. Penfield. Am. J. Sc. xxvii. p. 200.
 W. Hartley. J. Chem. Soc. xlv. p. 167.
 J. Lorenzen. Öfv. Vet. Ak. Förh. 2, p. 111. *New Min.; and Zs. K. ix. p. 248.*
 G. Tschermak. Ber. Ak. Wien. lxxxviii. (1), p. 1142. *Min.*
 J. Blasas. Ber. Ak. Wien. lxxxviii. (1), 1121. *Mon.*
 C. Trechmann. N. J. (1), p. 204. *Binnenthal.*
 L. Werveke. N. J. (2), p. 225. *Min.*
 A. Schrauf. Zs. K. ix. p. 457. *Cryst. Therm. &c.*
 E. Hussak. Verh. Geol. Reichs. p. 244. *Modriach.*

SAFFLORITE.

v. Spathiopyrite.

SALT.

W. Voigt. Ber. Ak. Berl. p. 989. *Elasticity.*

SALT AND SYLVITE.

A. Ben-Saude. Journ. Ac. Sc. Lisb. x. p. 43. *Opt.*

SAMARSKITE.

J. Donald. Chem. News, xlix. p. 259. *Berthier Co. Chem.*

SARCOLITE.

C. Rammelsberg. Zts. Geol. Ges. xxxvi. p. 222. *Chem.*

SAUSSURITE.

W. Clarke and T. Chatard. Am. J. Sc. xxviii. p. 21. *Chem.*

SCAPOLITE.

G. Tschermak. Ber. Ak. Wien. lxxxviii. (1), p. 1142. *Mon.*

C. Rammelsberg. Zts. Geol. Ges. xxxvi. p. 222. *Chem.*

A. Cathrein. Zs. K. ix. p. 378. *Pseud. after Garnet.*

SCHAFFNERITE.

v. Cuprodesclowitzite.

SCOLECITE.

V. Zepharovich. Zs. K. viii. p. 588. *Cryst.*

SCORODITE.

A. Verneuil and L. Bourgeois. Bull. Soc. Philomath. viii. p. 172. *Art.*

J. da Costa Sena. Bull. Soc. Min. vii. p. 218. *Ouro-Preto.*

v. Rhabdophane.

SCOVILLITE.

Schrader. Nat. Ver. Rheinl. Corr. Bl. p. 59. *Min.*

SELBECK.

- SERPENTINE. T. Bonney. Geol. Mag. Dec. 3. i. p. 406.
- SILVER-ORES. C. John. Jahrb. Geol. Reichs. xxxiv. p. 754. *Bosnia. Chem.*
- SISMONDINE. A. Descloizeaux. Bull. Soc. Min. vii. p. 80. *Opt.*
- SMITHSONITE. A. Schmidt. Term. Füz. vii. pp. 84, 127. *Pelšez-Ardó.*
J. Loczka. Term. Füz. vii. pp. 82, 125. *Chem.*
- SPATHIOPHYRITE. F. Sandberger. N. J. (1), p. 69.
- SPHENE. J. Bachinger. Min. Mitth. vi. p. 50. *Fuchs.*
- STAINZ. E. Hussak. Verh. Geol. Reichs. p. 244. *Minerals of.*
- STEPHANITE. G. v. Rath. Verh. Nat. Ver. Rheinl. p. 324. *Cryst.*
C. Morton. Zs. K. ix. p. 238. *Kongsberg. Cryst; and Öfv.*
Vet. Ak. Förh. 2. p. 99.
- STIBNITE. A. Brun. Arch. Sc. Phys. Nat. xi. p. 514. *Japan. Cryst.*
E. Dana. Zs. K. ix. p. 29. *Japan. Cryst.*
Wada. Ber. Ges. Nat. Fr. Berl. p. 80. *Japan.*
H. Foullon. Verh. Geol. Reichs. p. 142. *Chalcedony pseud.*
after, &c.
O. Mügge. N. J. (1), p. 55. *Hardness, &c.*
- STILBITE. O. Lüdecke. Zs. Naturwiss. Halle. lvii. p. 678. *Loc.*
- STOLZEMBURG. v. Copper Ores.
- STONEHAM (MAINE). G. Kunz. Am. J. Sc. xxvii. p. 212. *Minerals of.*
- SUMMIT DISTRICT, COL. R. Hills. Proc. Col. Sc. Soc. i. p. 20. *Ores of.*
- SUTHERLAND. M. Heddle. Min. Mag. v. p. 271. *Minerals of.*
- SYLVITE. v. Salt.
- SZABOITE. J. Krenner. Ber. Ung. ii. p. 215. *Mon.; and Zs. ix. p. 25.*
- TABOR. F. Safránek. Ber. Böhm. Ges. 1883, p. 355. *Minerals of.*
- TANTALITE. C. Schaeffer. Am. J. Sc. xxviii. p. 430. *Dakota.*
- TARNOWITZITE. C. Langer. Zs. K. ix. p. 196.
- TASMANIA. A. Groddeck. Zts. Geol. Ges. xxxvi. p. 642. *Stanniferous*
Deposits.
- TELLURIUM. H. Foullon. Verh. Geol. Reichs. p. 268. *Facseabaja.*
- TEPHROITE. A. Descloizeaux. Bull. Soc. Min. vii. p. 86.
- TETRAHEDRITE. A. Cathrein. Zs. K. ix. p. 353. *Kogel. Cryst.*
E. Doll. Verh. Geol. Reichs. p. 131. *Pseud. after Copper*
Pyrites.
F. Sandberger. N. J. (1), p. 70.
F. Babanek. Min. Mitth. vi. p. 82. *Przibram. Chem.*
O. Mügge. N. J. (2), p. 1. *Cryst. &c.*
- THENARDITE. } H. Gorceix. Bull. Soc. Min. vii. p. 179. *Minas. Geraes.*
- TITANIUM HYDRATE, }
 &c. }
TOPAZ. O. Mügge. N. J. (1), p. 60. *Hardness, &c.*
A. Kenngott. N. J. (1), p. 187. *Brazil.*
A. Groddeck. Zts. Geol. Ges. xxxvi. p. 647. *Tasmania.*
G. Kunz. Am. J. Sc. xxxvii. p. 212. *Maine.*
L. Grünhut. Zs. K. ix. p. 113. *Cryst.*
Wada. Ber. Ges. Nat. Fr. Berl. p. 82. *Japan.*
A. Groddeck. Zts. Geol. Ges. xxxvi. p. 648. *Tasmania.*
J. Bachinger. Min. Mitth. vi. p. 48. *Fuchs.*
- TOURMALINE.

- TOURMALINE. F. Gonnard. Bull. Soc. Min. vii. p. 65. *Haute-Loire. Min.*
Wada. Ber. Ges. Nat. Fr. Berl. p. 82. *Japan.*
R. Solly. Min. Mag. vi. p. 80. *Cryst.*
G. Kunz. Am. J. Sc. xxvii. p. 303. *Auburn. Maine.*
C. Dölter. N. J. (2), p. 221. *Therm. Opt.*
F. Stenger. Pogg. xxii. p. 522. *Therm.*
- TRIDYMIT. G. v. Rath. Verh. Nat. Ver. Rheinl. p. 326. *Krakatoa.*
A. Merian. N. J. (1), p. 193. *Opt.*
v. Stoneham.
- TRIPHYLITE. v. Stoneham.
- TRIPLITE. v. Stoneham.
- TRIPOLI. A. Gottschaldt. Dingl. J. ccliii. p. 533. *Chem.*
- TURQUOISE. N. Kokscharow. Bull. Ac. St. Pet. xxix. p. 352. *Kirghis-
Steppe.*
E. Tietze. Verh. Geol. Reichs. p. 93. *Nischapur.*
M. Ossent. Zs. K. ix. p. 563. *Minerals of.*
G. Rocco. Boll. Com. Geol. xv. p. 129. *Minerals of.*
O. Mügge. N. J. (1), p. 216.
- TYSONITE. E. Dana. Am. J. Sc. xxvii. p. 481. *Cryst.*; and Zs. K. ix. p. 284.
- URANINITE. C. Blomstrand. Ann. Chim. Phys. iv. p. 129. *Chem.*
- URANIUM MINERALS. v. Uraninite.
- URANIUM ORE. J. Lorenzen. Nyt. Mag. xxviii. p. 249. *Moss. Chem.*
- URANITE. Baret. Bull. Soc. Min. vii. p. 460. *Orvault.*
- UTAHITE. A. Arzruni. Bull. Soc. Min. vii. p. 126. *Utah. New Min.*;
and Zs. K. ix. p. 558.
A. Damour. Bull. Soc. Min. vii. p. 128. *Chem.*
- VALENTINITE. H. Laspeyres. Zs. K. ix. pp. 162, 192. *Cryst. and Pseud.*
- VANADINITE. F. Blake. Am. J. Sc. xxviii. p. 145. *Arizona.*
M. Websky. Ber. Ak. Berl. p. 661. *Chem. (with Idunium).*
- VIVIANITE. W. Clarke and T. Chatard. Am. J. Sc. xxviii. p. 25. *Washington.*
F. Smith. Proc. Cottes. Nat. p. 112.
O. Mügge. N. J. (1), p. 53. *Hardness, &c.*
- WERNEBITE. G. Tschermak. Ber. Ak. Wien. lxxxviii. (1), p. 1142. *Min.*
C. Rammelsberg. Zts. Geol. Ges. xxxvi. p. 222. *Chem.*
- WHEWELLITE. A. Weisbach. N. J. (2), p. 48. *Plauen.*
- WOLLASTONITE. N. Kokscharow. Bull. Ac. St. Pet. xxix. p. 298. *Kirghis-
Steppe*; and Verh. Russ. Min. Ges. xix. p. 153.
J. Loczka. Term. Fiz. viii. pp. 82, 124. *Chem. Resbanya.*
- WULFENITE. V. Zepharovich. Lotos, xxxiii. p. 28. *Carinthia. Cryst.*;
and Zs. K. viii. p. 583. *With Lime.*
- WURTZITE. H. Laspeyres. Zs. K. ix. p. 186. *Felsöbanya.*
- XANTHO-ARSENITE. L. Igelström and E. Bertrand. Bull. Soc. Min. vii. p. 237. *New Min.*

- XANTHOPHYLLITE.** P. Nicolajew. Verh. Russ. Min. Ges. xix. p. 28. *Chem.*
- ZEOLITES.** F. Gonnard. C. R. xcviii. p. 1067. *Loc.*
- ZINCITE.** F. Rinne. N. J. (2), p. 164. *Cryst.*
- ZINCKENITE.** W. Hillebrand. Proc. Col. Sc. Soc. i. p. 121. *Colorado. Chem.*
- ZINC-ORES.** v. Lead ores.
- ZIRCON.** K. de Kroustchoff. Bull. Soc. Min. vii. p. 222. *Beucha.*
C. Dölter and E. Hussak. N. J. (1), p. 43. *Melting Products, &c.*
v. Stoneham.
- ZOISITE.** W. Bell. Min. Mag. vi. p. 109. *Ross-shire.*
V. Zepharovich. Lotos. xxxiii. p. 38. *Carinthia.*
- ZUNYITE.** W. Hillebrand. Proc. Col. Sc. Soc. i. p. 124. *New Min. Colorado.*

1883 (*continued*).

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- HECTORITE.** S. Cox. Trans. N. Z. Inst. xv. p. 409. *New Min.*
- MENEGHINITE.** B. Harrington. Trans. Roy. Soc. Can. i. p. 79. *Canada. Chem.*
- MONTÉ CATINI.** L. Mazzuoli. Boll. Com. Geol. xiv. p. 220. *Copper Ore of.*
- NEW MINERAL.** v. Hectorite.
- NEW ZEALAND.** S. Cox. Trans. N. Z. Inst. xv. p. 361. *Minerals of.*
- PLATINUM.** J. Pond. Trans. N. Z. Inst. xv. p. 419. *Loc.*
- SERPENTINE.** B. Lotti. Boll. Com. Geol. xiv. p. 281. *Italy.*
- S. AUSTRALIA.** T. Cloud. Roy. Soc. S. Aust. vi. p. 72. *Minerals of.*
- STRONTIANITE.** B. Harrington. Trans. Roy. Soc. Can. i. p. 81. *Canada.*
- TENNANTITE.** B. Harrington. Trans. Roy. Soc. Can. i. p. 80. *Canada. Chem.*
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LIST OF ABBREVIATIONS USED IN INDEX.

See also Vol. vi. pp. 142, 187.

AN. SOC. ESP. HIST. NAT.	{	Anales de la Sociedad Española di Historia Natural. Madrid.
AN. SOC. ARG.		Anales Sociedad Científica Argentina. Beunas Aires.
ANN. SOC. AGR. LYON.		Annales de la Société d'Agriculture, Histoire naturelle, et Arts utiles. Lyon.
ANN. SOC. LINN. LYON.		Annales de la Société Linnéene. Lyon.
ARCH. MUS. RIO JAN.		Archives do Museo Nacional do Rio de Janeiro. Rio de Janeiro.
BRIT. KENNT. RUSS. REICH.	{	Beiträge zur Kenntniss des Russischen Reiches und der Angrenzenden Länder Asiens. St. Petersburg.
BIBL. EC. H. ET.		Bibliothèque de l'Ecole des Hautes Etudes. Paris.
BOLL. COM. GEOL.		Bolletino del R. Comitato Geologico d' Italia. Roma.
BOMB. R. AS. SOC.		Bombay Branch of the Royal Asiatic Society. Bombay.
BULL. AM. MUS.		Bulletin of the American Museum of Natural History. New York.
BULL. BUFF. SOC.		Bulletin of the Buffalo Society of Natural History. Buffalo.
BULL. ESS. INST.		Bulletin of the Essex Institute. Salem, Mass.
BULL. SOC. NANCY.		Bulletin de la Société des Sciences de Nancy. Nancy.
BULL. SOC. NORM.		Bulletin de la Société Linnéene de Normandie. Caen.
BULL. SOC. PHILOM.		Bulletin de la Société Philomathique de Paris. Paris.
BULL. SOC. TOUL.		Bulletin de la Société de Histoire Naturelle de Toulouse. Toulouse.
JAHRESB. SCHLES. GES.		Jahresbericht der Schlesischen Gesellschaft für vaterländische Cultur. Breslau.
JAHREB. KARP. VER.		Jahrbuch des Siebenbürgischen Karpathen-Vereins. Hermannstadt.
J. SOC. CINC.		Journal of the Cincinnati Society of Natural History. Cincinnati.
KORREL. VER. RIGA.		Korrespondenzblatt des Naturforscher Vereins zu Riga. Riga.
MEM. AC. BOST.		Memoirs of the American Academy of Arts and Sciences. Boston.
MÉM. AC. CAEN.		Mémoires de l'Académie Royale des Sciences, Arts, et Belles-lettres. Caen.
MÉM. AC. DIJ.		Mémoires de l'Académie des Sciences, Arts, et Belles-lettres. Dijon.
MEM. AC. MAD.		Memorias de la Real Academia de Ciencias Físicas y Naturaes de Madrid. Madrid.

MÉM. AC. ROUEN.	Mémoires de l'Académie de Rouen. Rouen.
MÉM. BOST. SOC.	Memoirs of the Boston Society of Natural History. Boston
MÉM. SOC. BORD.	Mémoires de la Société des Sciences physiques et naturelles de Bordeaux. Bordeaux.
MÉM. SOC. CHERB.	Mémoires de la Société des Sciences Naturelles. Cherbourg.
MÉM. SOC. LILLE.	Mémoires de la Société Royale des Sciences, de l'Agriculture et des Arts. Lille.
MÉM. SOC. SEINE.	Mémoires de la Société des Sciences Naturelles de Seine et Oise. Versailles.
NAT. TIJDS. NED.-IND.	Naturkundig Tijdschrift voor Nederlandsch-Indië. Batavia.
N. Z. INST.	Transactions and Proceedings of the New Zealand Institute. Wellington.
NOUV. MÉM. MOSC.	Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscow. Moscow.
PROC. AS. SOC. BENG.	Proceedings of the Asiatic Society of Bengal. Calcutta.
PROC. CAN. INST.	Proceedings of the Canadian Institute. Toronto.
PROC. COL. SOC.	Proceedings of the Colorado Scientific Society. Colorado.
PROC. LINN. SOC. N. S. W.	} Proceedings of the Linnean Society of New South Wales. Sydney.
REV. CIENC. MAD.	
	Revista de los Progres de los Ciencias exactas físicas y naturales de Madrid. Madrid.
REV. SCI.	Revue Scientifique. Paris.
R. SOC. CAN.	Proceedings and Transactions of the Royal Society of Canada. Montreal.
R. SOC. N. S. WALES.	Journal and Proceedings of the Royal Society of New South Wales. Sydney.
R. SOC. VIOT.	Transactions and Proceedings of the Royal Society of Victoria. Melbourne.
S. SCI. REC.	The Southern Science Record. Melbourne.
TIJDS. IND.	Tijdschrift voor Indische Taal-, Land- en Volkens-kunde. Batavia.
TRANS. AC. CONN.	Transactions of the Connecticut Academy of Arts and Sciences. New Haven.
TRANS. AC. ST. L.	The Transactions of the Academy of Science of St. Louis. St. Louis.
TRANS. R. SOC. S. AUST.	Transactions of the Royal Society of S. Australia. Adelaide.
ZTS. FERD.	Zeitschrift des Ferdinandeums für Tirol und Vorarlberg. Innsbruck.
<i>Art.</i>	Artificial.
<i>Mon.</i>	Monograph.
<i>Pseud.</i>	Pseudomorph.

Abstracts.

F. Genth and G. vom Rath (*Zeits. f. Krystallographie und Mineralogie*, X. p. 458) describe certain Vanadates and Silver Iodide from Lake Valley, Donna Anna County, New Mexico.

The minerals described are (1) Vanadinite. (2) A new mineral occurring in small yellowish-white hexagonal prisms, and having the composition $Pb_2 Cl (AsO_4)_3 + Pb_2 Cl (VO_4)_3$. It has only been found in very small quantities; the name *Endlichite* is here given to the mineral. (3) Descloizite occurs in small red or black crystals, which sometimes attain a length of 6 mm., associated with Pyrolusite, Psilomelane, &c. Their composition is expressed by the formula — $Pb_2 [HO] VO_4 + Zn_2 [HO] VO_4$, where Zn is partly replaced by Mn, Cu, Fe, and V to a slight extent by As and P. No traces were found of the new element Idunium, discovered by Prof. Websky in the Vanadates from Lake Valley. There is a notable difference between the Argentine Descloizite and that from Lake Valley, for while the former contains only 2.54 per cent. of zinc oxide, the latter contains 17.41 per cent. The Argentine crystals were found by Des Cloizeaux to be rhombic, but Websky suggested that they might be oblique and twinned; the crystals from New Mexico are here shown to be rhombic, a conclusion in which Websky now concurs. Confirmatory evidence is supplied by an optical examination undertaken by Des Cloizeaux. (4) Silver Iodide occurs in small and imperfect yellow crystals; one specimen showed indications of a twin structure hitherto unobserved on this mineral, the plane of twinning being parallel to $\frac{1}{2} P = \{10 . 1 . 1\}$.

G. vom Rath (p. 475 of the same Journal) gives a crystallographic description of the quartz from Burke Co., N. Carolina, of which the mode of occurrence is similar to that from Alexander Co. (*v. Min. Mag.* VI. p. 146). An attempt is here made to utilise the triangular markings so common on the pyramid faces as a means of determining whether the crystals are right- or left-handed, simple or twinned. The author finds that they have two unequal sides parallel to the pyramid edges; of these the greater is always nearer to the corner on which the face $\{412\}$ appears or might be expected to appear. The markings on $+ R \{100\}$ have sharp outlines and are bounded by smooth surfaces, those on $- R, \{221\}$ have their shortest side convex and formed of a rounded surface.

The character and positions of these markings on any part of a face will therefore show whether they belong to $+ R$ or to $- R$, and whether to a right- or a left-handed crystal.

Among the crystals described, one is noteworthy as exhibiting twin lamellæ parallel to a face of $+R$, and as having one of its ends right-handed while the other is left-handed.

Several new faces are described besides the rare forms P_2 , $\{5\bar{2}1\}$, $-\frac{3}{2}P_2$, $\{21\bar{1}\}$, $\frac{4}{3}P_3$, $\{10.1.\bar{2}\}$, which all appear well developed.

Method of determining Opaque Minerals by the Microscope.—M. A. Inostranzeff (*Comptes Rendus*, Vol. c. 1885, p. 1896) describes an apparatus to which he gives the name of *Comparison Chamber*, and which renders it possible to identify opaque minerals in rocks. For this purpose two microscopes are used: in one is placed the rock section containing the mineral to be determined, in the other can be placed standard examples of known minerals; both of these are brilliantly illuminated from above.

The microscopes are without eye-pieces, and upon them is fixed the comparison chamber; this is a horizontal tube through which the rays that emerge from the microscopes are deflected by means of prisms at the two ends of the tube; at the centre are two prisms which project these rays upwards into an eye-piece fixed above the chamber in such a way that a circular field of view is obtained, of which one half belongs to one microscope and half to the other; the field will only appear uniform when the two minerals are absolutely identical in lustre and colour. The author reserves for a later paper further details concerning the scale of minerals used for comparison, and the method of illumination.

The Thinolite of Lake Lahontan.—The 12th Bulletin of the United States Geological Survey is a crystallographic study of thinolite by Prof. E. S. Dana (Washington, 1884). The calcareous tufas of the Lahontan basin were described under this name by C. King, in the Geological Exploration of the 40th parallel (Vol. I. p. 488). They form a crystalline deposit consisting of carbonate of lime, obviously pseudomorphous after some mineral which was thrown down in enormous quantities at some period in the history of this basin. The very imperfect skeleton crystals of thinolite have hitherto been supposed, in accordance with King's suggestion, to be pseudomorphs after Gaylussite, but a careful microscopic examination has convinced Prof. Dana that the original form was a tetragonal pyramid, having a terminal angle of $95\frac{1}{4}^\circ$. This leads to the suggestion that the original mineral may have been a chloro-carbonate of lime isomorphous with phosgenite, *i.e.* having the formula $\text{Ca CO}_3 : \text{Ca Cl}_2$. Prof. Dana is also of opinion that the Gaylussite pseudomorphs of Sangerhausen and other localities ("the barleycorn" pseudomorphs) are also in reality pseudomorphs of calcite after the same mineral as that which formed the original material of the thinolite.

RUSSIAN CENTRAL ASIA, INCLUDING KULDJA, BOKHARA, MERV. By HENRY LANSDELL, D.D. (Sampson, Low & Co., London, 1885).—In these two volumes Dr. Lansdell, in addition to the record of an adventurous journey, pleasantly told, gives much information as to the natural history and geology of this little-known region. He does not confine himself to what may have come under his own observation during his journey, but has brought together much information from the writings of Russian men of science, which gives his work an exceptional value.

Turkestan contains, we learn, in workable amounts, the following metals and rocks:—Gold, silver, lead, copper, iron, manganese, arsenic, turquoise, agalmatolite, graphite, mineral oil, petroleum, mineral and lake salt, native sulphur, sal ammoniac, alum, copperas, iron pyrites, porphyry, gypsum, and marble.

Besides limestone, gypsum and clay, some 6,500 tons of oil are obtained annually, of which three-fourths come from the Kuldja region and the remainder from the Syr-daria Territory. The Kuldja district likewise produces about 5,000 tons of coal a year, and that of the Syr-daria about 1,600 tons more; but of the other useful minerals most are unworked, in several instances it is doubted whether the amount is sufficient to render working, on any extensive scale, remunerative. The gold is found in alluvial deposits in minute nuggets or "dust," and the deposits are not rich. Some of the galena is argentiferous, but the ordinary ores of silver are not found. Turquoise is supplied by one deposit only, in Mount Karamazar, in a decomposed "felspar porphyry" cut by veins of diabase. Petroleum is obtained only in Ferghana, from a fossiliferous sandy limestone of cretaceous age. Altogether the mineral resources of the region traversed by Dr. Lansdell do not seem great in comparison with its extent.

L. J. IGELSTRÖM has analysed (*Bull. Soc. Min. de France*, Tome VIII. p. 421) some pure crystals of Braunite from Jacobsberg, Wermland, Sweden; the results of five analyses according with those of the mineral from Elgersburg, Thuringia. Two determinations of the silica gave 8.09 and 9.25 per cent., thus corresponding with the analyses already made, with the exception of that by Turner, which the author believes to be inaccurate. The silica is not mechanically mixed, as it is supposed to be by some mineralogists, as the strongest magnifying powers failed to detect any impurity in the crystals analysed; it is doubtless an essential constituent. The author believes that the manganese is present as MnO_2 and not as Mn_2O_3 , and suggests that the true formula should be that given by Dana, viz. $2 (2 MnO \cdot MnO_2) + MnO_2 \cdot SiO_2$.

M. A. LACROIX has examined, by means of the microscope, the minerals to which the names of Harringtonite, Bowlingite, Kirwanite and Hullite have been given (*Bull. Soc. Min. de France*, Tome VIII. pp. 96, 97, 428). The Harringtonite examined was a piece given by Thomson himself (who analysed and named it) to Des Cloizeaux. It is not a homogeneous substance. With polarised light it proved to be an isotropic mass enclosing crystals belonging to two distinct species of zeolite, having different optical properties, probably natrolite and mesolite. Bowlingite consists of a green fibrous mineral, ortho-rhombic or oblique in crystallisation, enclosed in a magma of a serpentinous substance which is entirely isotropic. This substance also occurs as inclusions in the fibres. Kirwanite consists of a fibrous green substance, the optical properties of which approach those of the hornblendes. Lacroix points out that it is always surrounded by a pale yellow aureola, which consists of granular quartz and epidote. H. Fischer of Freiburg had earlier (1871) noted that some Kirwanite was mixed with a felspathic mineral. Hullite, like the preceding, is a mixture. A thin section shows that the mass is isotropic and contains inclusions of magnetite, calcite, and fragments of felspar. The author is of opinion that these substances cannot be regarded as distinct species.

INDEX TO VOL. VI.

	PAGE
Council Meeting, April 3rd, 1884	i.
Council Meeting, July 3rd, 1884	i.
Council Meeting, October 21st, 1884	i.
General Meeting, June 24th, 1884	i.
Anniversary Meeting, October 21st, 1884	iii.
Annual Report for 1883-84	iv.
List of Donations	vi. xii. xx.
Council Meeting, December 9th, 1884	ix.
Council Meeting, March 10th, 1885	ix.
Receipts and Payments	x.
General Meeting, December 9th, 1884	xi.
General Meeting, March 10th, 1885	xi.
Council Meeting, June 25th, 1885	xiii.
General Meeting, June 16th, 1885	xiii.
Council Meeting, October 20th, 1885	xv.
Anniversary Meeting, October 20th, 1885	xvi.
Annual Report for 1884-85	xvi.

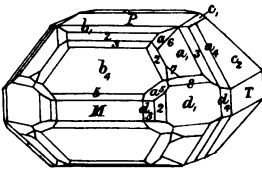


Fig. 1.

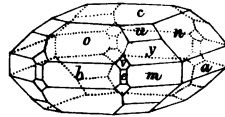


Fig. 2. Endellion.

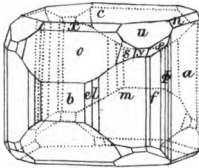


Fig. 3. Liskeard.

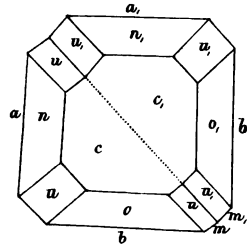


Fig. 4.

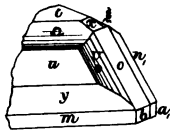


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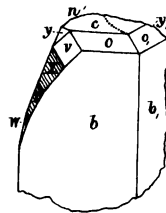


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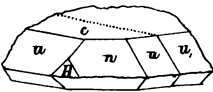


Fig. 7.

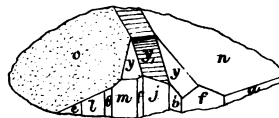


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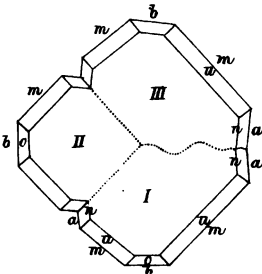


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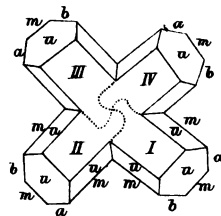


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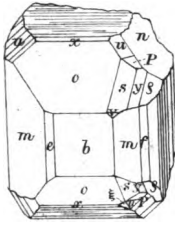


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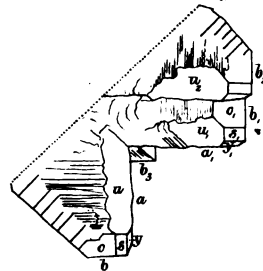


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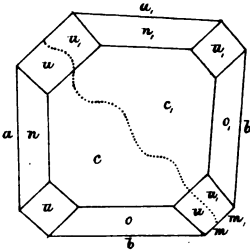


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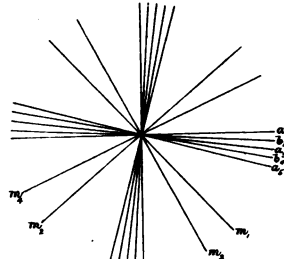
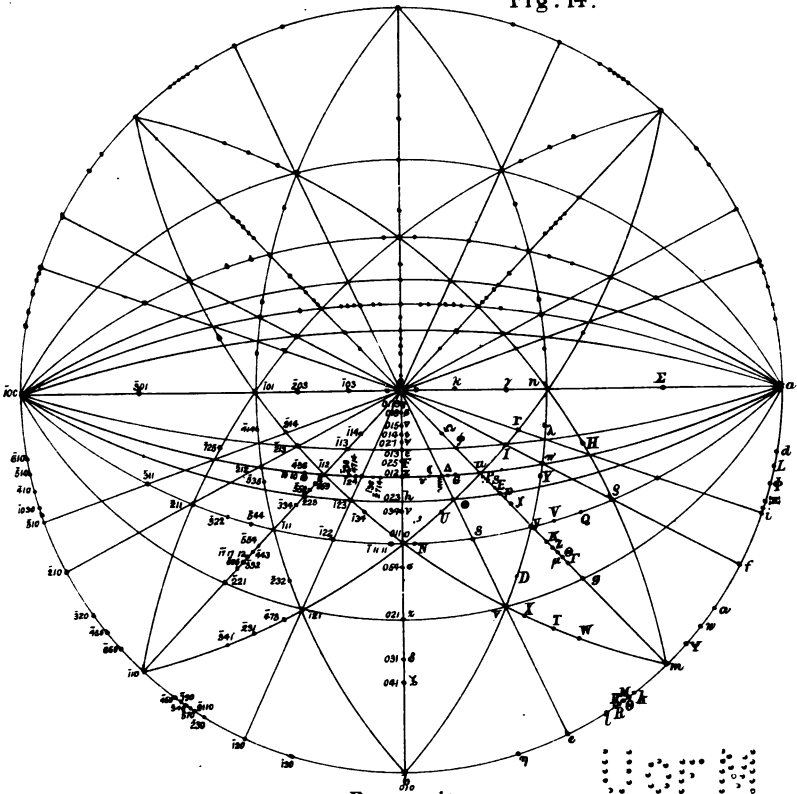


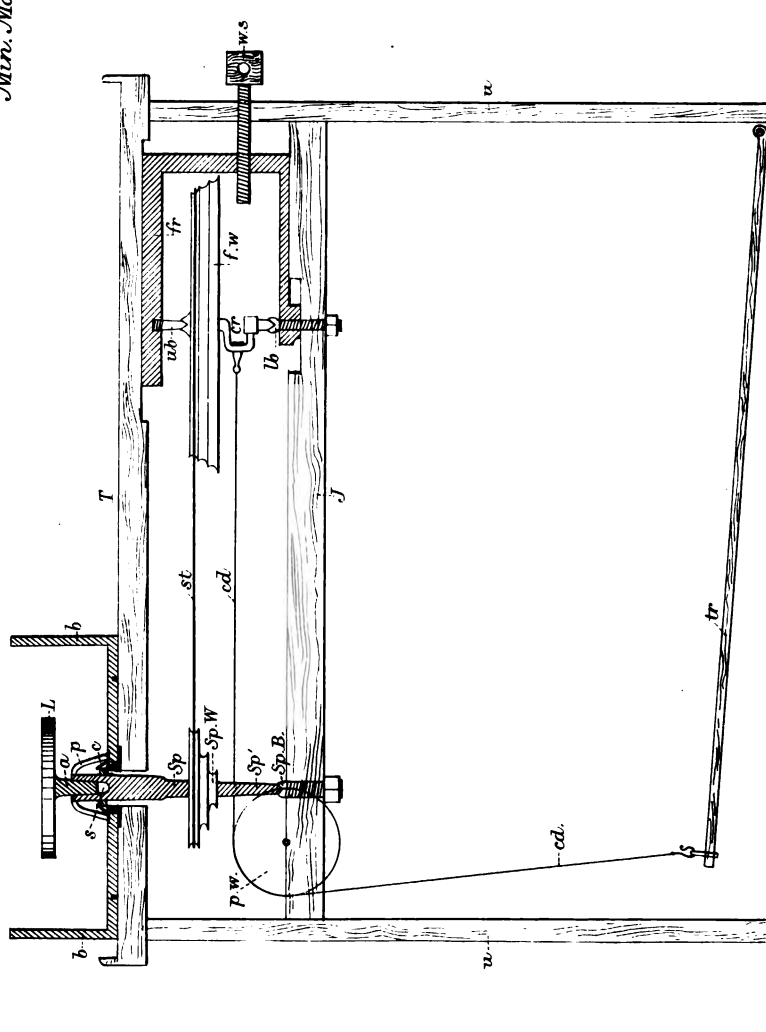
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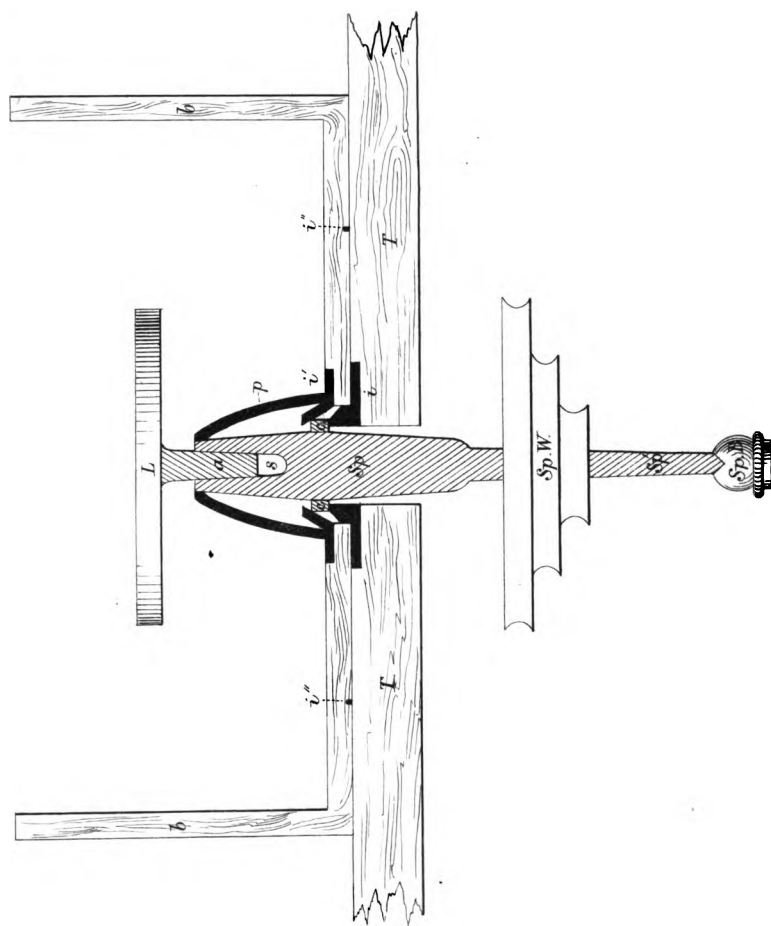
Bourbonite.

Mintern Bros. lith.

W. H. R.



Diagrammatic section & drawing of Lapidary's Lathe.



Enlarged diagram of Grinding Apparatus.

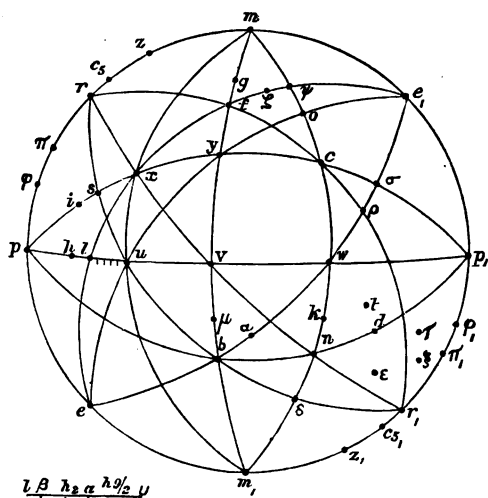


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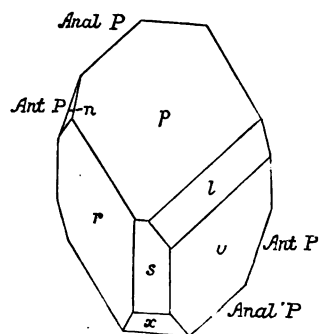


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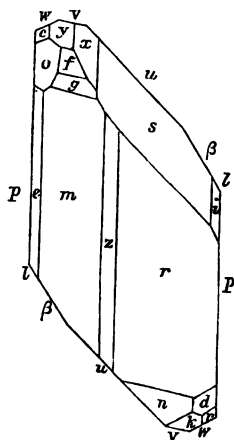


FIG. 3.

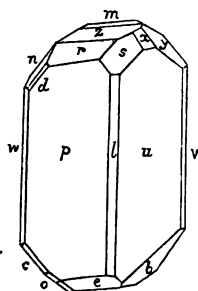


FIG. 4.

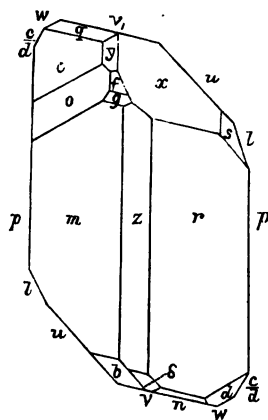


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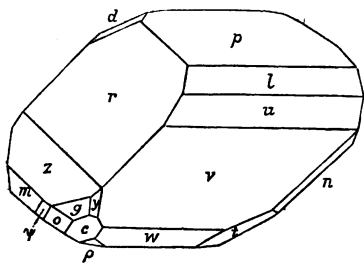


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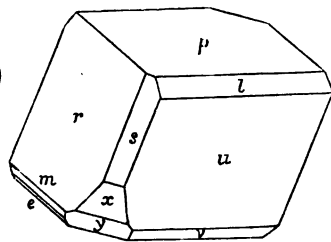


FIG. 7.

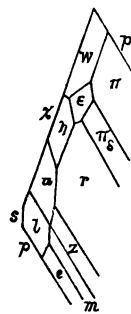


FIG. 8.

P A P E R S, & c.

	PAGE
Aberdeenshire, Andalusite Schists of	98
————, Graphite from	172
Abstracts and Notes	145, 192, 234
Actinolite	126
ADY, Mr. J. E., on Mineral and Rock Sections for Microscope ..	127
Albertite	101
Amazonstone	127
Andalusite Schists	98
Andesite	43, 44
Anorthitfels	5, 9, 11, 14
Argyllshire, Strontianite from	173
Arran Pitchstones	xiii.
Asbestos	203
Asuk, Iron of	4, 7, 14, 22, 23
Atacamite	163
Axinite	203, 211
Azurite	125
“Barleycorn” Pseudomorphs	235
Barrhead, Native Copper from	xiii.
Barytes of Scotland	168
Basalt of Greenland, Nickel-iron in	1
BELL, Mr. W. H., on a New Locality for Zoisite	109
Blaafjeld (Ovifak, or Uifak), Iron of	2-18, 31-33
Bog Butter (Butyrellite)	175
BONNEY, Rev. Prof., Presidential Addresses of	xvii. 111, 195
————, on Lava from Old Providence Island	39
————, on Replacement of Quartz by Fluor-spar	48
————, on Picrite, &c. from Gipps' Land, and Serpentine from Tasmania ..	54
————, on Impediments to Mineralogical Science.. .. .	114
Bournonite	59, 60, 73
Bowlingite	237
Braunite	237
Brochantite	161-163, 167
Butyrellite	175
CADWELL, Mr. H. M., on Metallic Veins of the Upper Harz	90
Calcite	120, 203
California, Colemanite from	147
CARNELLEY, Dr. T., on Application of Periodic Law to Mineralogy ..	83
Ceylon, Graphite from	152

	PAGE
Chalcophyllite	167
Chenevixite	125, 182
Chessylite	167
Chrysocolla	125
Clarite	49, 51
Clausthal, Metallic Veins of	93
Coins, Cuprite Crystals on	xix.
Colemanite	xix. 147
Comparison Chamber for identifying Minerals	235
Cone-in-Cone Structures	xiii.
Conichalcite	125, 181
Connellite	160, 164, 171
Copenhagen Museum, Meteoric Iron in	25, 27
Copper Minerals from Utah	181
Copper Pyrites	203
Cornwall, Chenevixite from	182
———, Connellite of	160, 171
———, Minerals from	202
———, Monazite from	164
Cornwallite	125
CRODNER on Artificial Crystals	121
Cross, Mr. Whitman, on Rare Minerals from Utah	212
Cryolite	148
Crystal of Parisite	123
——— of Tourmaline	80
Crystalline Form of Tin	148
Crystallographic Study of Danburite	xviii. 213
Crystallographical Society, reference to	111
Crystallography of Bournonite	59
Crystals of Calcite	120
——— of Graphite	151
Cuprite Crystals on Roman Coins	xix.
DANA, Prof. E. S., on Thinolite	235
Danburite	xviii., 213
DAUBRÉE, M., Experiments of	199, 200
DAWSON, Mr. W. E., on a Mineral found near Pretoria	xviii.
Devon, Minerals from	202
Diatomite, Analyses of	88, 89
Diatoms, Deposits of	87
Diorite	55
Eksaluit, Iron from Grave at	6, 7, 16, 29
Enargite	49, 124
Endlichite	234
Esquimaux, Iron used by	2, 6, 7, 24, 29, 30
Encrite	2-5

INDEX.

241

PAGE

Famatinite	49, 51
Felspars of Pantelleria	192
Finland, Graphite from	152
Fluor-spar from Holmbush Mine.. .. .	202
———, Replacement of Quartz by	48
FORSTNER, H., on Felspars of Pantelleria	192
FOUILLON, H. Baron v., on Crystalline Form of Tin	148
FOUQUÉ, M., Experiments of	199, 200
Garnet	202
———, New Mode of Occurrence of	46
GENTH, F., on Vanadates, &c. from New Mexico	234
Gipps' Land, Picrite from	54
Glasgow District, Minerals from	xiii.
GLEN, Mr. D. C., on Minerals from Scotland.. .. .	xiii.
Gold of Wales	108
GRANDMAISON, M. Guyot de, on Parisite	123
Granite of Scotland	168
Graphic Granite	168
Graphite	151, 172
Greenland, Cryolite of	148
———, Iron in Grave of	6, 7, 16, 29
———, Nickel-iron in Basalt of	1
———, Telluric Iron of	14
Greenockite	xiii.
Grinding Instruments for Rock Sections	131
GRÖDDECK, Dr., his work on "Ore Deposits"	98
Guayacanite	51
Harringtonite	237
Harz, Upper, Metallic Veins of	90
HEDDLE, Prof., on Zoisite	109
Helton Beacon Lead Mine, altered Siderite from	52
HERMAN, Mr., Experiments of	200
HILLEBRAND, Dr., on rare Minerals from Utah	212
HORNE, Mr. J., on Andalusite Schists of Aberdeenshire.. .. .	98
Hornstone	203
Hullite	237
IGELSTRÖM, M., on Braunitz	237
Index to Mineralogical Papers, 1883-84	184-144, 183-191, 217-233
INOSTRANZEFF, M., on determining Opaque Minerals by Microscope	235
Iron Pyrites	203
Iron, Telluric, of Greenland	14
Jalghaba (Russia), Variolite of	145
Jasper	203
Jet Mineral of Midlothian	ii.

	PAGE
JOHNSTADT, Prof., on Iron of Greenland	3, 4, 10, 11
JUDD, Prof., on Scotch Minerals	199
Kieselguhr	88
Kirkhill, Limestone of	170
Kirwanite	237
KLEIN, C., on Optical Studies of Leucite	193
Knives of the Esquimaux	2, 6, 24, 29, 30
Krakatoa, Trydimite from	147
Kyanite	106
LACROIX, M., on Harringtonite, &c.	237
Lake Lahontan, Thinolite of	235
LANSDELL, Dr. H., on Minerals, &c. of Russian Central Asia	236
Lapidary's Machine	131
Lava of Gipps' Land	56
— of Old Providence Island	39
LAWSON-LESSING, M., on Variolite	145
Lead Chromate from near Pretoria	xix.
Leucite	193
LÉVY, M., Experiments of	199, 200
Lherzolite	55
Limestone, Minerals associated with	170
LORENZEN, Dr., on Greenland Telluric Iron	14
LOUIS, Mr. H., on New Mode of Occurrence of Garnet	46
Luxullianite	48
Luzonite	49, 51
MACADAM, Mr. W. I., on Butyrellite	175
—, on Diatomaceous Deposits in Scotland	87
—, on Graphite from Aberdeenshire	172
—, on Strontianite from Argyllshire	173
MACKENZIE, Dr. G. S., on rare Copper Minerals from Utah	181
—, Note on Paper by	212
MASKELYNE, Prof., on Connellite	171
Mesosiderites	8
Metallic Veins, Explanation of the Origin of	95
— of the Harz	90
Meteorite from West Australia	xi.
Meteorites, Minerals in	1
Mexico, Stephanite from	147
Microscope, determining Opaque Minerals by	235
—, Mineral and Rock Sections for	127
Mid-Devon Copper Mine, Minerals from	202
Midlothian, Jet Mineral of	ii.
MIRRS, Mr. H. A., on the Crystallography of Bournonite	59
—, Index to Mineralogical Papers by	184, 183, 217
—, on Monazite and Connellite	164

	PAGE
Mineralogical Papers, Index to	134-144, 183-191, 217-233
Mineralogical Science, Impediments to	114
Mineralogy, Application of Periodic Law to	83
Minerals, improper naming of	14, 196
— in Meteorites	1
— from Cornwall and Devon	202
— from Glasgow District	xiii.
— from Russian Central Asia	236
— from Scotland	xiii.
— from Utah	212
—, Opaque, determining by Microscope	235
Mispickel	203
Monazite	164
Montana, Enargite of	49, 124
MORRISON, Mr. W., on Strathpeffer Albertite	101
MÜGG, O., on Cryolite	148
Native Copper from Barrhead	xiii.
New Granada, Parisite of	123
New Mexico, Vanadates, &c. from	234
Nickel-iron in Basalt of Greenland	1
NORRÉ's Dynamite Company, reference to	88
NORDENSKIÖLD, Prof., on Iron of Greenland	2-5
North Carolina, Quartz from	146, 234
Oil of Russian Central Asia.. ..	236
Old Providence Island, Lava from	39
Olivenite	125
Opaque Minerals determined by the Microscope	235
Ovifak. <i>See</i> Blasfjeld.	
Palæopierite	54
Pantelleria, Felspars of	192
Pargas (Finland), Graphite from	152
Parisite	123
Pectolite	104
Periodic Law, Application of, to Mineralogy.. ..	83
Peru, Brochantite from	163
Petroleum of Russian Central Asia	236
PETTON, Rev. W. W., on Actinolite in Scotland	126
Pierite (Palæopierite)	54
Pitchstones	xiii.
PLANT, Mr. J., on Bog Butter	175
Prehnite	104
Presidential Addresses	xvii. 111, 195
Pretoria, Mineral found near	xviii.
Pyrenees, Occurrence of Garnet in the.. ..	46

	PAGE
Quartz from North Carolina	146, 234
———, Replacement of, by Fluor-spar	48
RAMMELSBURG on Azinite	209
RATH, G. vom, Notices of Minerals by	146
———, on Vanadates, &c. from New Mexico	234
READWIN, Mr. T. A., on Welsh Gold	108
Roman Coins, Cuprite Crystals on	xix.
Roman Gravels Mine, Calcite from	121
RUSKIN, Mr. John, on Forms of Silica	i.
Russia, Variolite of	145
Russian Central Asia, Rocks, &c. of	236
RUTLEY, Mr., Experiments of	200
Saint Andreasberg, Silver Mines of	122
———, Silver Veins of	94
Salisbury Crag, Rocks of	104
Samson's Ribs, Rocks of	104
Schists, Andalusite	98
SCHUSTER, Dr. Max, on Danburite	xviii. 213
Scotland, Actinolite in	126
———, Cone-in-Cone Structures from	xiii.
———, Diatomaceous Deposits in	87
———, Kyanite Localities of	106
———, Minerals of	xiii. 168
Sections for Microscope, preparation of	127
Semi-Opal	203
SEMMONS, Mr. W., on Connellite	160
———, on Enargite	49, 124
Serpentine from Tasmania	54
Siderite, altered	52
Sierra Nevada, Andesites of	44
Silica, Forms of	i.
Silver Iodide	234
Silver Veins and Silver Mines of Saint Andreasberg	94, 122
SJÖGEREN, H., on Graphite	151
SMITH, Prof. L., on Iron of Greenland	4, 5, 11, 15, 16, 32-38
SOLLY, Mr. R. H., on a Crystal of Tourmaline	80
———, on Crystals of Calcite	120
———, on Minerals from Cornwall and Devon	202
Sowallick, Iron from	2
Spain, Conichalcite from	181
Sphene	164
Spherulites	xiii.
Staurolite	107
STEENSTRUP, Mr. K. J. V., on Nickel-iron in Greenland Basalt	1-13
———, references to	14, 15, 30-38
Stephanite	147

INDEX.

245

PAGE

Stibnite	50
Strathpeffer, Albertite of	101
Strontianite	173
Sweden, Braunite of	237
Switzerland, Danburite of	214
Tankerville Mine, Calcite Crystals from	120
Tasmania, Serpentine from	54
TAYLOR, Mr. A., on Prehnite, &c.	104
TEALL, Mr. J. J. H., on Lavas from Old Providence Island	41
Telluric Iron of Greenland	14
Thinolite	235
THOMSON, Mr., on a Jet Mineral of Midlothian	ii.
Thumerstein	204
Tin, Crystalline Form of	148
Tinstone of Virginia	xi.
TÖRNEBOHM, Dr., on Iron of Greenland.. .. .	5, 11, 14, 33-37
Tourmaline	80
TRECHMANN, Dr., on Connellite	161, 171
———, on Siderite	52
Tridymite	147
Troilite	2, 4, 5, 14
Trowlesworthite.. .. .	48
Turkestan, Metals and Rocks of	236
Turnerite	164
Twins of Bournonite	73
——— of Graphite	153-155, 159
Tyndrum Galena-vein	93
Uifak. See Blaafjeld.	
Utah, Copper Minerals from	181
——, rare Minerals from	212
Vanadates	234
Variolite	145
Veins, Metallic, of the Harz	90
Violet Stone	204
Virginia, Tinstone of	xi.
Wales, Gold in	108
WALLACE, Mr. T., on Kyanite in the North	106
———, on Northern Minerals	168
Wermland, Artificial Graphite from	152
West Australia, Meteorite from	xi.
Widmanstätten's Figures in Iron of Greenland Basalt	1
Wölschite	65

Yanolite	PAGE
	204
YOUNG, Mr. J., on Cone-in-Cone Structures from Scotland	xiii.
Zeolitic Minerals	xv.
ZIRKEL, Prof., on Crystallography of Bournonite	60
Zoisite	109

